INFLUENCE OF MANURES ON GROWTH AND YIELD OF FIVE CHILLI GERMPLASM

MD. SHOFIQUL ISLAM

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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BY

MD. SHOFIQUL ISLAM

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APPROVED BY:

Prof. Md. Ruhul Amin	**Prof. Dr. A. F. M. Jamal Uddin**
Department of Horticulture	Department of Horticulture
SAU, Dhaka-1207	SAU, Dhaka-1207
Supervisor	**Co-Supervisor**

Prof. Dr. Tahmina Mostarin
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Ref. No. : Date :

CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF MANURES ON GROWTH AND YIELD OF FIVE CHILLI GERMPLASM"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by **MD. SHOFIQUL ISLAM**, Registration No. **10-03800** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated: June, 2016
Dhaka, Bangladesh

Prof. Md. Ruhul Amin
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor


Dedicated To
My Beloved Parents

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The Author

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from September 2015 to January 2016. The experiment was consisted of two factors: Factor A: Five germplasm of chili viz; G_1: Tree chili, G_2: Surjomukhi, G_3: Bullet, G_4: Agni, G_5: Cayenee. Factor B : 4 levels of manure viz; O_0: No manure (control), O_1: Cowdung 10 t ha^{-1}, O_2: Vermicompost 5 t ha^{-1}, O_3 : Mustard oil cake 2 t ha^{-1}. There were 20 treatment combinations. The experiment was laid out in Randomized Complete Block Design with three replications. In different germplasm the maximum vitamin C content (149.96 mg/100g), capsaicin content (1.64 %), yield ha^{-1} (14.51 t/ha) were recorded from G_5 and the minimum results were recorded from G_1. Due to different manures application, the maximum yield ha^{-1} (8.43 t/ha) were recorded from O_2 but the maximum vitamin C content (128.27 mg/100 g) and maximum capsaicin content (1.23 %) were recorded from the O_3 and minimum data were recorded from O_0. For interaction effect, the maximum yield ha^{-1} (17.06 t/ha) were recorded from G_5O_2 but the maximum vitamin C content (161.33 mg /100 g) and maximum capsaicin content (1.83 %) were recorded from G_5O_3. Minimum capsaicin content (0.70 %), minimum yield ha^{-1} (1.16 t/ha) were recorded from G_1O_0 and minimum vitamin C content (92.50 mg /100 g) was obtained from G_1O_1. In this experiment the Cayenee germplasm and vermicompost performed the best results in maximum parameters.

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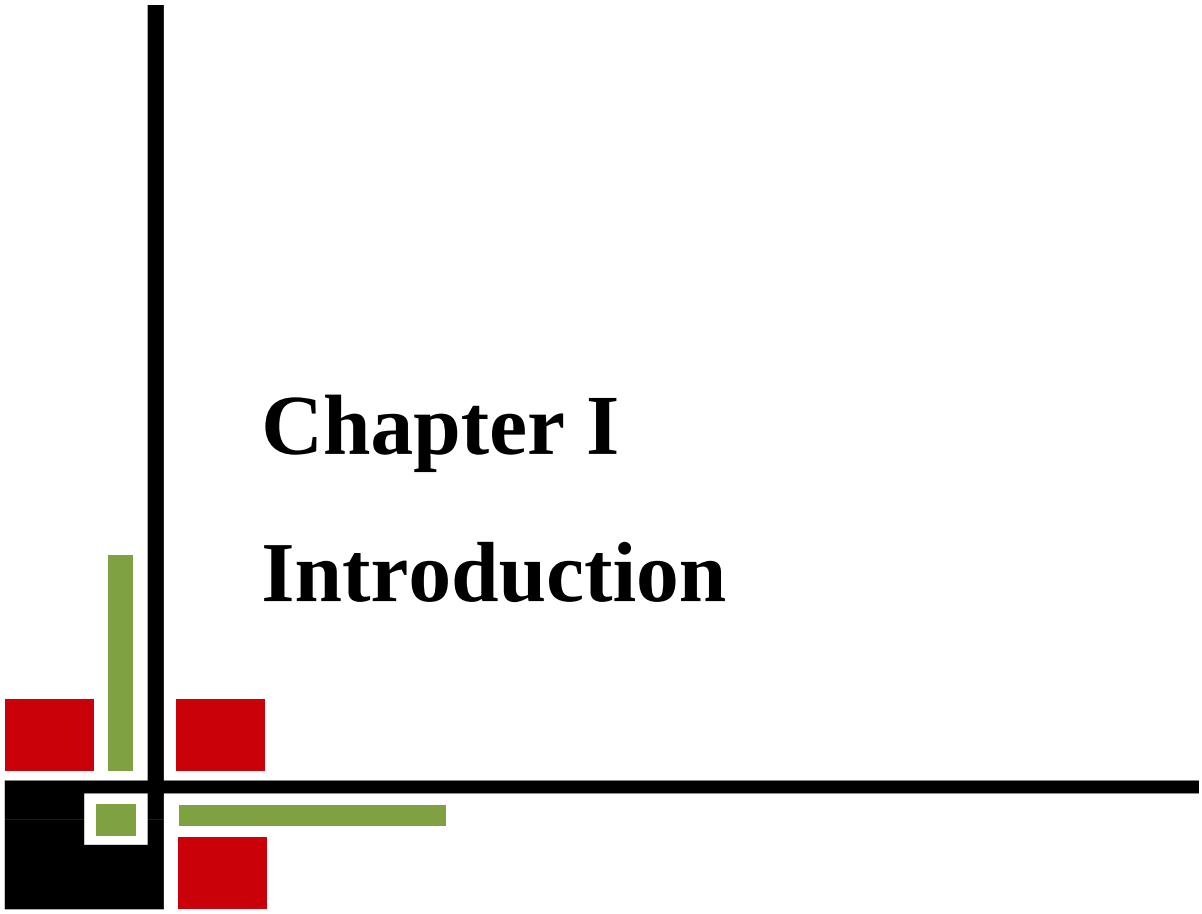
LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
a.i	Active ingredient
Adv.	Advanced
Agron .	Agronomy
Agric.	Agriculture
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
RCBD	Randomized Complete Block Design
CV	Coefficient of Variation
cv.	Cultivar
EC	Emulsifiable Concentrate
cm	Centimeter
df	Degrees of Freedom
DAS	Days After Sowing
LSD	Least significance difference
et al.	and others
etc.	Etcetera
FAO	Food and Agricultural Organization
Fig.	Figure

ABBREVIATIONS	ELABORATIONS
J.	Journal
PP.	Pages
g	Gram
ha^{-1}	Per hectare
t	Ton
%	Percent
m^2	Square meter
kg	Kilogram
No.	Number
NS	Non Significant
^0C	Degree Celsius
Res.	Research
RH	Relative humidity
WCE	Weed control efficiency
SRDI	Soil Resource Development Institute
Sci.	Science ’s
HI	Harvest Index
Vol.	Volume



Chapter I

Introduction

CHAPTER I

INTRODUCTION

Chili (*Capsicum frutescens* L.) is one of the very important vegetable and spice crops member of Solanaceae family. It's grown on commercial scale in Bangladesh, having the chromosome number 2n=24 and originated from tropical America especially Brazil. They are normally short lived perennials in subtropical and tropical areas, but they normally grown as annuals in colder regions. Plants are normally small bushes. Flower is solitary, extra axillary, sometimes occurs in pairs, actinomorphic, pedicellate, bisexual and hypogynious. Chili plant is often cross-pollinated crop and visited by pollen carrying insects. It is one of the most important vegetable which is valued around the world for the color, flavor, spice, and nutritional value. It is virtually an indispensible item in the kitchen for daily cooking. It contains different types of protein, vitamin, ascorbic acid, and also is a good source of medicinal potential. It is mostly being liked for its pungency, spicy taste besides the appealing colors it adds to the food. The pungent nature of chilli is due to crystalline volatile alkaloid substance called capsaicin ($C_9H_{14}O_2$).

The total cultivated area and production of chili in 2004-2005 were 1,54,655 hectares and 186000 metric tons, respectively (BBS, 2005). In 2010-2011 total average production of green chili in Bangladesh was only about 1.69 ton⁄ ha because of lacking of better cultivar. The total cultivated area under spices and condiments is 793 thousand acres (BBS, 2013). The total cultivated area covered by chilli is about 352 thousands acres (BBS, 2014) and total production of chilli is about 185 thousands M. Tons (BBS, 2014). Winter chilli contributes about 90 % of its total production (Anonymous, 1987). In Bangladesh, the harvest price of chilli is about Tk. 56,100/M. Ton (BBS, 2015). Average yield of dry chili is very low in Bangladesh when compare with neighboring countries.

Organic manures are organic materials which are more environmental friendly compare to chemical fertilizers. Fruits harvested from plant receiving organic fertilizers were compact, lower acidity, attractive color and fruit yield with better quality (Singh *et al*., 2010; Islam, 2003). Cow dung, vermicompost and Mustard oil cake are excellent organic manures which are commonly used for crop production. Cow dung is important organic manure. It is also called the life of soil and plays an important role for sustainable soil fertility and crop productivity. The greatest benefit form cycling and recycling of organic matter in soils is the overall improvement in soil environment as well as supplying nutrients especially N, P, K and S. Well rotten cowdung is also a good source of plant nutrient. It not only provide nutrient but also improve the soil physical and chemical properties like porosity water-holding capacity. It has been widely used for increasing crop production.

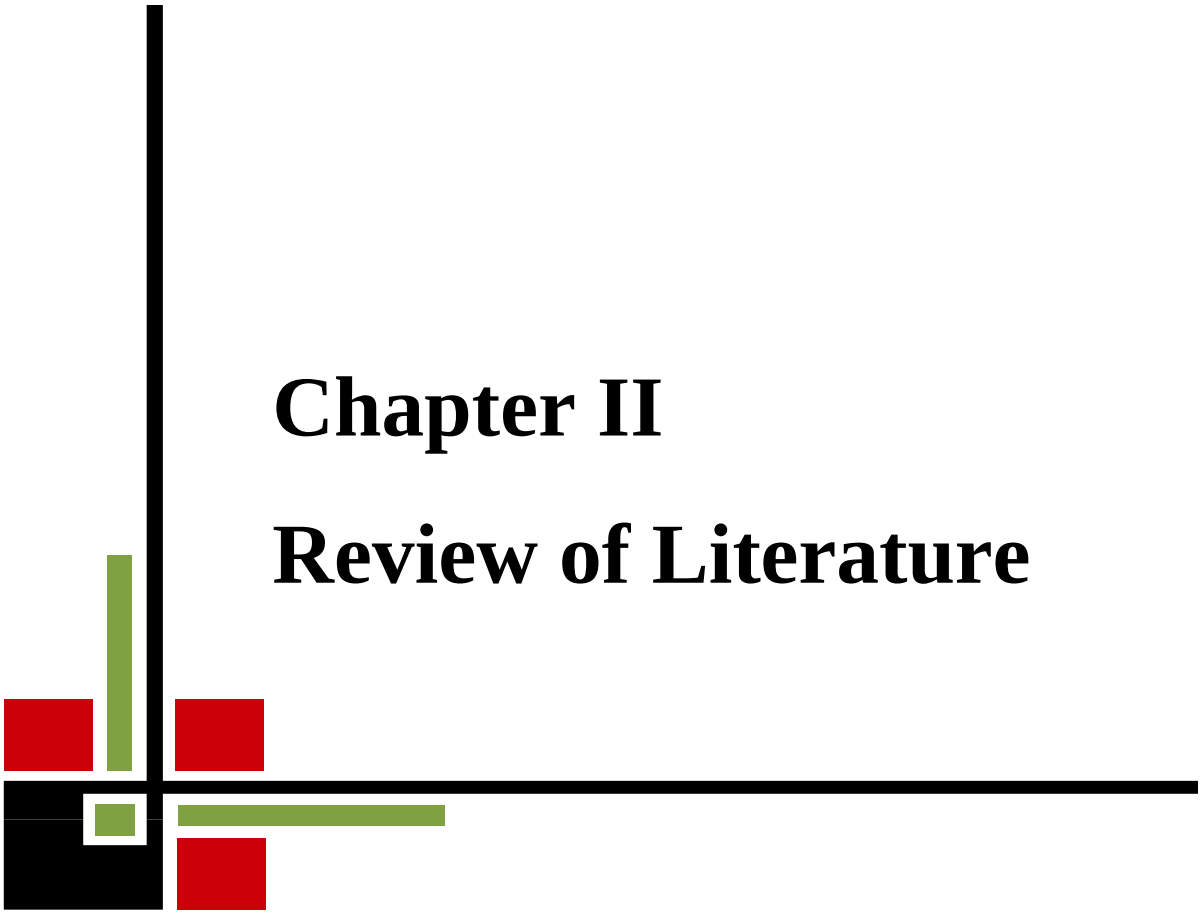
Vermicompost is a product of non-thermophilic biodegradation of organic material by combined action of earthworms and associated microbes. Vermicompost has high levels of available NPK and micro nutrients, microbial and enzyme activities and growth regulators. Its continuous use with proper management can increase soil organic carbon, soil water retention, soil water transmission, improvement in other physical properties of soil like bulk density, penetration resistance, aggregation as well as beneficial effect on growth of a variety of plants. It is ecofriendly and improved indexes of yield like fruit length, number of fruit and fruit weight (Atefe *et al.,* 2012; Daniel and Jader, 2012). Vermicompost products represent a crucial eco-friendly technology capable of recycling organic wastes to be utilized as fertilizers. Mustard oil cake has unique properties that make it a favorable fertilizer and even herbicide source. Growers can get both fertilizer and pesticide benefits from mustard meals. It has been shown to control weeds, insect pests, nematodes and pathogens (Boydston *et al.,* 2007; Mazzola *et al.,* 2007; Rice *et al.,* 2007; Vaughn *et al.,* 2006; Norsworthy and Meehan, 2005; Chung *et al.,* 2002; Elberson *et al.,* 1996, 1997; Walker, 1996).

In Bangladesh most of the cultivated chili is local and hybrid. Most common chili varieties are release from Bangladesh Agricultural Research Institute and also by some other private research organization, but there is lack of potential pungent, hot and high yielding chili variety. In that case some good germplasm of chili is required to establish in Bangladesh with combination of using different organic manure. Tree chili, Surjomukhi, Bullet, Agni and Cayenne are some well known and high demandable varieties of chili.

Organic manure's provides several benefits by minimizing production cost and it is an environmentally friendly method of cultivation. Addition of organic fertilizers improves soil structure and enhances activities of useful soil organisms (Nakhro *et al*., 2010). In recent times, consumers are demanding higher quality and safer food and highly interested in organic products (Ouda *et al*.,2008). Inorganic fertilizer is made up from synthetic materials, when excess of application occur, the soil will become toxic. However, a growing awareness of the adverse impacts of inorganic fertilizers on crop production as well as increasing environmental and ecological concerns has stimulated greater interest in the utilization of organic amendments for crop production. Thus, this study intends to provide an alternative method by using several of organic treatment for enhancing growth, yield and quality of chilli.

In the light of the above perspective, the present experiment was conducted with chilli as the test crop having different combination of organic manures to find out the best combination of manures for chilli production. Considering the above fact the study was undertaken on following objectives:

i. To find out the influence of manures on growth and yield of chilli
ii. To find out the suitable cultivar for cultivation in Bangladesh
iii. To evaluate the combined effect of manures and chilli germplasm on different growth parameters and yield



Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Chilli is one of the most important spice crop in the world as well as in Bangladesh. Many experiments were conducted in home and abroad on the nutritional requirement of chilli. But information regarding the combined effects of cow dung, vermicompost and mustard oil cake in chilli is meagre. The research findings related to the present investigation so far in country and abroad have been reviewed are presented below.

2.1 Review in relation to manure

Khandaker *et al.* (2017) observed that the effects of different organic fertilizers on growth, yield and quality of *Capsicum annuum* L. var Kulai (Red Chilli Kulai). Performance of chilli plant was assessed by application of different organic fertilizer (vermicompost (VC), chicken dung (CiD), peat moss (PM), fermented fish waste (FFW), and cow dung (CoD)).Application of vermicompost and chicken dung shows highest growth, quality and yield performance. Control treatment (without organic fertilizer) showed the lowest growth, yield and quality response.

Ishtiyaq *et al.* (2015) investigated that different rates of vermicompost produced varied and significant effect (P\0.05) as compared to the control on germination, growth and yield parameters with maximum value recorded at 6 t/ha, followed by 4 t/ha and the least at 2 t/ha. The dose of 6 t/ha significantly (P\0.05) increased germination (22.56 ± 2.5 %), number of fruits per plant (3.55 ± 0.07) mean fruit weight (73± 5.0 g), yield per plant (1.48 ± 0.05 kg) and marketable fruits (28.66 ± 3.0 %) when compared with the control.

Rehman *et al.* (2015) observed that bio management of root knot nematode, *M. incognita* affecting chilli using non edible seed oil cakes is an effective and ecologically safer approach as a substitute of nematicides for the pollution free and sustainable environment.

Ali *et al.* (2014) conducted an experiment to investigate the potential of vermicompost and mustard oil cake leachate as foliar organic fertilizer with reference to the growth, yield and TSS status of chilli and BARI hybrid tomato 8 and then examined their effects on different parameters. The experimental data revealed that significant increase in growth; yield and TSS on chilli and BARI hybrid tomato-8 were observed due to foliar application of vermicompost and mustard oil cake. All parameters performed better results with the foliar application of the leachate from vermicompost which was very close the mustard oil cake. However, maximum number of fruit, yield and TSS were found from the foliar application of leachate from vermicompost which was followed by mustard oil cake (28.4 /plant, 12.7 kg/plot and 4.2% respectively) whereas minimum from control.

Reshid *et al.* (2014) reported that a plastic pot set-up with soil was used to determine the effects and efficiency level of vermicompost on the growth and yields of tomatoes (*Solanum lycopersicum* L.). The study was conducted through effect of increasing concentration of Vermicompost (control, 10%, 20%, 30% and 40%w/w) in target plant growth. The obtained results from the present research indicated that applied vermicompost especially; at 20% level had significantly improving effects on better growth and development of vermicompost treated tomatoes as they had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields. Low doses of vermicompost (10%) and high doses (40%) produced lower yields of the tomato plants. Generally, the addition of vermicompost led to improve the yield of tomato cultivars as compared to control. Hence, it could be suggested that treated plants, with this vermicompost increased the growth, yield and the above chemical compositions and pH of the soil.

Singh *et al.* (2014) observed the effect of organics on growth yield and biochemical parameters in chilli. The results show that better plant height, number of leaves, number of branches, number of flower, number of fruit, fresh weight and dry weight per plant consisting of treatment FYM (12.5t/ha) +

Vermicompost (2.5t/ha) + Biofertilizer (@2.5kg/ha Azospirillum + PSB) The biochemical parameters like the Chlorophyll a, and b, carotenoid, protein and abscorbic acid were recorded maximum in with organics FYM (12.5t/ha) + Vermicompost (2.5t/ha) + Biofertilizer (@2.5kg/ha Azospirillum + PSB.

Khalid *et al.* (2013) conducted an experiment using six different organic amendments on strawberry (*Fragaria ananassa* Duch.) cv. Chandler which included T_1 = planting media (soil + silt + farm yard manure); T_2 = planting media + 400 mg/L humic acid; T_3 = planting media + 200 g /kg leaf manure; T_4 = planting media + 200 g/kg vermicompost; T_5 = planting media + 200 g/kg plant fertilizer and T_6 = planting media + 200 g/kg bio-compost. Hence farm yard manure (FYM) and vermicompost based organic amendments enhanced vegetative growth and improved quality of strawberry fruits.

Kumar *et al.* (2013) reported that organic manures proved to be superior when compared to the fertilizers as regards pest incidence. Vermicompost was significantly more effective as regards fruit borer infestation. NSKE 5% extract proved to be the most effective against fruit borer. Neemgold (*Azadirachtin*) 5 ml/l, *Pongamia glabra* 5% leaf extract and *Annona squamosa* 5% leaf extract also were effective in reducing the fruit borer incidence. *Murraya koenigi* 5% extract and chilli-garlic 5% extract were less effective. Significantly highest marketable yield was obtained in Neemgold (*Azadirachtin*) 5 ml/l followed by NSKE 5%.

Vanmathi and Selvakumari (2012) conducted an experiment on *Hibiscus esculentus* and allowed to grow in the medium of vermicompost and urea to examine the effect of vermicompost and urea on the growth and yield. There were 3 treatments viz., control, vermicompost (T_1) and urea (T_2). From the study, maximum plant height (19.8 cm), number of flower (21.3), number of fruit (15.0), fruit weight (10.3 g), total fruit weight (185.0 g) and fruit length (12.3 cm) was found from the application of vermicompost on *Hibiscus esculentus.*

Mamta *et al.* (2012) conducted an experiment on the effect of vermicompost on the growth and productivity of chilli plant. The vermicompost of cow dung, garden waste and kitchen waste in combination were used with chilli plants under field conditions. The different treatments affected the seed germination of the test crop significantly. Plant height, number of branches, number of leaves, number of flowers and fruit weight ware higher in the vermicompost treated field as compared to control and no disease incidence was observed in the fruits of vermicompost treated plot. The study revealed that vermicompost amendments affected chilli crop differently and we recommend that while raising chilli crop farmers should use vermicompost instead of synthetic fertilizers.

Lallawmsanga *et al.* (2012) conducted an experiment and said that the ameliorating effect of vermicompost and cowdung compost on growth and biochemical characteristics of *Solanum melongena* treated with paint industrial effluent was evaluated in this study. The color and odor of the effluent samples, physical and chemical parameters like pH, EC, TDS, TS, EC and heavy metals were analyzed. The effluent contained sulphates, chlorides, phosphates, dissolved solids and other pollutants in higher amounts. The effect of effluent with water, vermicompost and cow dung were studied on shoot length, root length, leaf area, fresh weight, dry weight and biochemical parameters like Chlorophyll a, Chlorophyll b, Total Chlorophyll and Carotenoids of *S. melongena.* There was no change in the chlorophyll content on 80% effluent with vermicompost when compared to the control, whereas reduction in the carotenoids content was noted in 80% effluent with vermicompost.

Attarde *et al.* (2012) investigated the effect of organic and inorganic fertilizers on growth and nutrient status of *Abelmoschus esculentus* (okra plant). For the experiment, various combinations of fertilizers such as Vermicompost (VC), Chemical Fertilizer (CF) and Farmyard Manure (FYM) were applied by followings, T_1: Control, T_2: (FYM 100%), T_3: (VC 100%), T_4: (CF 100%), T_5: (VC 75% + CF 25%), T_6: (VC 75% + FYM 25%), T_7: (VC 50% + FYM 50%)

and T_8: (VC 50% + CF 50%). The study indicated that that with the use of inorganic fertilizers plants physical characteristics were enhanced compared to other treatments whereas nutrient status of okra fruit was recorded maximum in treatment T_3 (VC 100%) and followed by T_6 (VC 75% + FYM 25%).

Hatamzadeh and Masouleh (2011) observed the effects of vermicompost on growth and productivity of chilli. plants grown in a container medium including 50% pumice, 30% charcoal, 10% vermiculite and 10% peat moss, which was basic plant growth medium substituted with 10%, 20%, 30% and 40% (by volume) vermicompost besides control consisted of container medium alone without vermicompost Greatest vegetative growth resulted from substitution of container medium with 30% and 40% vermicompost and lowest growth was in potting mixtures containing 0% vermicompost.

Cristina and Jorge (2011) reported that vermicompost can be described as a complex mixture of earthworm faeces, humified organic matter and microorganisms that when added to the soil or plant growing media, increases germination, growth, flowering, fruit production and accelerates the development of a wide range of plant species. The enhanced plant growth may be attributed to biologically mediated mechanisms such as the supply of plantgrowth regulating substances and improvements in soil biological functions. Stimulation of plant growth may depend mainly on biological characteristics of vermicompost, plant species used and cultivation conditions

Ali *et al.* (2011) shows the effect of Panchagavya and Sanjibani, liquid organic manure on the yield of green gram (*Vigna radiata*), chilli (*Capsicum frutescens*) and mustard (*Brassica campestris*). Their efficacy were compared by studying the yield contributing characters like plant height, primary branch, secondary branch/plant, number of seed/fruit, fruit length, weight of 100 seed, yield/plant, yield m^{-2} and experimental observation recorded that the Sanjibani and Panchagavya treated crops were higher than the control. A liquid manure specifically Sanjibani used in this study was pre-analysed to study the variation in microbial population between two Sanjibani sample prepared by using raw

materials (Cow dung and Cow urine) obtained from two different source of cow breed (i.e., Native breed and Jersey breed) and the best source of breed was selected for the further research work. Meanwhile the effect of organic farming practice in soil-health was also studied by analysing the basic parameters of soil in the field were the research was conducted. The result shows increased microbial population, oxidisable organic carbon, nitrogen, phosphate, potash. The pH and E.C were found to be close to neutral.

Goutam *et al.* (2011) conducted field trials using different fertilizers having equal concentration of nutrients to determine their impact on different growth parameters of tomato plants. Six types of experimental plots were prepared where T_1 was kept as control and five others were treated by different category of fertilizers (T_2-Chemical fertilizers, T_3-Farm Yard Manure (FYM), T_4-Vermicompost, T_5 and T_6- FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively).The treatment plots (T_6) showed 73% better yield of fruits than control, Besides, vermicompost supplemented with N P K treated plots (T_5) displayed better results with regard to fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches and number of fruits per plant from other fertilizers treated plants.

Amir and Ishaq (2011) reported the importance of composts as a source of humus and nutrients to increase the growth of plant. Different composts (Vermicompost and Pitcompost) and garden soil (Control) were taken for the chemical analysis firstly and then to find the effect of these composts on the growth of a vegetative crop 'Pisum sativum'. From the chemical analysis it was found that vermicompost was rich in nutrients like potassium, nitrate, Sodium, calcium, magnesium and chloride and have the potential for improving plant growth than pit compost and garden soil (control).

Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate with maximum number of leaves, height, leaf length, number of fruits and productivity.

Joshi and Vig (2010) reported that various growth, yield and quality parameters like mean stem diameter, plant height, yield/plant, leaf number, fruit length, total plant biomass, ascorbic acid, titrable acidity, soluble solids, insoluble solids and pH were increased significantly when treated with vermicompost.

Manatad and Jaquias (2008) evaluated growth and yield performance of vegetables as influenced by the application of different rates of vermicompost. Findings of their study exposed that fruit length, diameter, weight of fruits/plant and yield was significantly enhanced by vermicompost application in chilli, egg plant, sweet pepper and tomato.

Jagadeesha (2008) reported that the effect of organic manures and biofertilziers on plant growth, seed yield and quality parameters in tomato. Application of RDF (60:50:30 kg NPK/ha) + biofertilzier (Azospirillum and P solubilizing bacteria 2.5 kg/ha each) records higher plant height (64.37, 109.50 and 162.33 cm), number of leaves (92.50, 153.33 and 146.50), leaf area (898.05, 4314.31 and 4310.94 cm^2) and leaf area index (898.05, 4314.31 and 4310.94 cm^2) at 30, 60 and 90 DAT respectively and records lesser days to 50 per cent flowering (38.00) followed by FYM (50%) + vermicompost (50%) + biofertilzier. The application of RDF + biofertilziers records higher seed yield (106.87 kg/ha) followed by FYM (50%) + vermicompost (50%) (101.94 kg/ha) over FYM alone. The seed yield was significantly higher with the application of RDF + biofertilziers was attributed to number of fruits per plant (45.22) number of seeds per fruit (109.45) fruit weight per plant (1280.98 g) and 1000 seed weight (2.84 g).

Ullah *et al.* (2008) reported that combined treatment (60 % organic +40% inorganic) showed the best performances. The maximum branching (20.1) with the highest number fruits/plant (15.2), fruit length (14.1 cm) and fruit diameter (4.3 cm) were found combined application of manures and fertilizers. The highest yield (45.5 t ha^{-1}) was also obtained from the combined application of organic and inorganic sources of nutrients. Application of mustard oil cake or

poultry manure alone gave better performance compared to only chemical fertilizers. The organic matter content and availability of N, P, K and S in soil were increased by organic matter application. On the other hand soil pH was increased with chemical application than organic.

Kattimani and Shashidhara (2006) recorded that Vietnam-2 significantly higher yield (932 kg/ha) compared with Byadagi dabbi and Byadagi kaddi. The values of growth and yield components were also significantly higher in Vietnam-2. Application of FYM at 10 t/ha along with 100% recommended dose of fertilizer (RDF) resulted in higher fruit yield (919 kg/ha) compared to RDF alone. Similarly, application of FYM at 10 t/ha with 100% RDF increased oleoresin content and yield by 17.5 and 16.0%, respectively, over 100% RDF alone. Application of FYM at 10 t/ha along with 100% RDF enhanced the uptake of nutrients like N, P, K, Ca, S and Fe by 14.1, 44.9, 37.4, 15.5, 20.3 and 26.7 per cent, respectively, over RDF alone in Vietnam-2. Similar trend was also found in other genotypes. The maximum net returns (Rs. 28 522/ha) was recorded with the application of FYM at 10 t/ha + 100% RDF followed by FYM at 5 t/ha + chilli stalk at 5 t/ha + 100% RDF + secondary and micronutrient + biofertilizer (Rs. 25 638/ha) in Vietnam-2 compared to Byadagi kaddi and Byadagi dabbi.

Singh and Kushwah (2006) reported that application of 100% NPK+30 t FYM/ha resulted in significantly higher tuber yield of 456 q/ha compared with that of other treatments except 100% NPK+30 t Nadep/ha and 75% NPK+30 t FYM/ha. The effect of organic manures (FYM and Nadep compost) in combination with inorganic fertilizers was more pronounced compared with that of organic manures alone. However, FYM was more effective than Nadep compost in producing higher tuber yield. Maximum net return of Rs 63 627/ha was also obtained from 100% NPK+30 t FYM/ha. However, benefit:cost ratio was almost same under 75% NPK with 30 t/ha FYM or Nadep compost and 100% NPK with 30 t/ha FYM or Nadep compost.

Anju *et al.* (2006) studied on the influence of organic manures, biofertilizers and micronutrients of growth, yield and yield parameters of chilli. The results indicated that highest yield amount the organic manures was recorded by application poultry manure (1977 kg ha^{-1}) compare it the application of FYM (165 kg ha^{-1}) and no organic manure (1412 kg ha^{-1}) treatment. Seed treatment with biofertilizer Azaspirilhum was not significant. Among the micronutrients boron spray found significantly superior (1722 kg/ha) over the $MgSO_4$ spray (1641 kg ha^{-1}) and no micronutrient spray (1580 kg ha^{-1}) in terms of yield.

Arancon *et al.* (2006b) found that vermicomposts produced commercially from cattle manure, market food waste and recycled paper waste, were applied to tomatoes (*Lycopersicon esculentum*), bell peppers (*Capsicum anuum* grossum), and strawberries (*Fragaria* spp.). The marketable tomato yields in all vermicompost-treated plots were consistently greater than yields from the inorganic fertilizer-treated plots. Leaf areas, numbers of strawberry runners, numbers of flowers, shoot weights, and total marketable strawberry yields increased significantly in plots treated with vermicompost compared to those that received inorganic fertilizers.

Mamta *et al.* (2005) observed that the efficacy of several organic manures and organic pesticides alone and in combination with on organic fertilizers and chemical pesticides, for the control of leaf curl [Pepper leaf curl virus] and die-back (caused by *Collectrichum capsici*) diseases of chill (*Capsicum annuum*). The organic manures tested included farmyard manure (FYM), organic manure, organic manure – cellrich, neem cake and vermicompost.

Chaoui *et al.* (2005) made a report that vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium (NPK) and micro nutrients, microbial and enzyme activities and growth regulators.

Kushwah *et al.* (2005) observed that application of FYM, Nadep compost and vermicompost alone or in combination did not influence tuber yield significantly. However, organic manures at 7.5 t/ha in combination with 50%

recommended dose of NPK significantly increased tuber yield. The highest tuber yield (321 q/ha) was recorded with 100% recommended dose of NPK fertilizers. The highest incremental benefit cost ratio (7.5) was obtained with 50% recommended dose of NPK.

Ananthi *et al.* (2004) conducted that field experiments were carried out with chilli (*C. annuum*) cv. PKM 1 during the kharif and rabi seasons of 2001-02 in Coimbatore, Tamil Nadu, India. The treatments included 2 sources (muriate of potash (MoP) and sulfate of potash (SoP)) and 5 levels (0, 30, 45, 60 and 75 kg/ha) of K, with application of farmyard manure (FYM). Additional 2 treatments, i.e. 30 and 60 kg K< sub>2</ sub>O/ha as SOP, were tried without FYM. K at 60 kg SOP/ha increased the number of fruits per plant, fruit length and fruit weight during both seasons. This treatment also recorded the highest fruit set percentage, harvest index and dry fruit yield (5.77 and 5.09 t/ha during the kharif and rabi seasons, respectively). Economic analysis showed that application of K at 60 kg SOP/ha was significantly superior in increasing the net return and benefit cost ratio (5.80 and 5.11 during kharif and rabi, respectively).

Hangarge *et al.* (2004) reported that application of vermicompost at 5 t ha^{-1} + organic booster at 1 litre m-2, and soil conditioner (Tera care) at 2.5 t ha-1 + organic booster at 1 litre m^{-2} enhanced the availability of N, P, K and organic C content in soil. The recommended rates of NPK and organic sources each alone did not have any significant effect. The combined effect of organic + organic sources proved to be better than either organic alone or combination of organic + inorganic fertilizer.

Maheswari *et al.* (2004) conducted that the effects of foliar organic fertilizers (amino acid at 0.5 and 0.75%; humic acid at 0.1 and 0.2%; and vermiwash at 1:3 and 1:5 vermiwash : water ratios) on the quality and economics of chilli (*C. annuum*) were investigated on sandy loam soil in Tamil Nadu, India. The recommended fertilizer rate was applied as basal and top dressing (complete dose; N:P:K at 160:60:30 kg/ha), and as basal application alone (80:60:30

kg/ha). The highest ascorbic acid content (175.23 mg/100 g) was observed in the treatment combination of vermiwash at 1:5 and basal and top fertilizer dressing. Capsaicin content and seed number were highest (0.49%) with 0.75% amino acid + complete fertilizer dose. Amino acid at 0.75% + complete fertilizer dose produced the best returns.

Subhasmita *et al.* (2004) shows that the effects of vermicompost based on karanj, niger, mahua, Indian mustard, groundnut or neem oilseed cake, and NPK (120:80:60 kg/ha) as control, on leaf damage by L. trifolii and on the yield of chilli cv. Suryamukhi were studied in a pot experiment. Leaf damage varied from 20.0 to 53.3%, whereas fruit yield per plant ranged from 9.7 to 21.3%. The vermicompost based on mahua oilseed cake resulted in the lowest percentage of leaf damage (16.7%), whereas the vermicompost based on groundnut oilseed cake recorded the highest fruit yield (21.3 g per plant).

Yadav and Vijayakumari (2004) reported that reducing sugar, free amino acid and phenol contents were higher in the vermicompost treatment on 30 (70.27, 7.98, 14.62 mg/g), 60 (95.51, 17.66, 22.32 mg/g) and 90 days after sowing (33.67, 3.17, 11.85 mg/g). The protein content was higher in vermicompost treatment on 60 and 90 days after sowing (113.37 and 79.69 mg/g, respectively), whereas it was higher in vermicompost+farmyard manure (FYM) treatment on 30 (35.73 mg/g) days after sowing. The carbohydrate content was higher in vermicompost+FYM treatment on 30 and 90 (4.67 and 6.46 mg/g, respectively) days after sowing, while on 60 days after sowing, it was higher in the vermicompost treatment (15.34 m/g). Chlorophyll a (0.23 mg/g), chlorophyll b (0.38 mg/g) and total chlorophyll (0.62 mg/g) were higher in vermicompost+neem cake treatment on 30 days after sowing. On 60 days after sowing, higher chlorophyll b (2.61 mg/g) and total chlorophyll (3.62 mg/g) contents were observed in the treatment containing vermicompost alone. On 90 days after sowing, chlorophyll a (1.01 mg/g) and total chlorophyll (1.92 mg/g) content was higher in vermicompost alone, and chlorophyll b (1.07 mg/g) in the vermicompost+FYM treatment.

Edwards *et al.* (2004) reported that vermicompost have fine particulate structure, low C: N ratio, with organic matter oxidized, stabilized and converted into humic materials. It contains nutrients transformed into plant available forms and are extremely microbially-active. Addition of low rate of substitution of vermicompost on plant growth media to field crops have consistently increases plant germination, growth, flowering, fruiting, independent of nutrient availability.

Hiranmai and Vijayakumari (2003) evaluated the effect of vermicompost applied singly and in combination with different organic manures (farmyard manure (FYM), composted coir pith, composted press mud, composted sugarcane trash, biofertilizer, green manure, and neem cake) and inorganic fertilizers on the biometric and yield parameters of chilli (Capsicum annuum). The biometric parameters varied significantly among the treatments. Vermicompost alone and admixed with FYM, green manure, neem cake and NPK fertilizers were effective in improving various biometric parameters. Better yield parameters were observed in the vermicompost treatment.

Maheswari *et al.* (2003) observed that application of 0.75% amino acid with complete (100%) dose of RDF resulted in the highest N and K uptake of 59.68 and 31.88 kg/ha, respectively. Application of vermiwash at 1:5 dilution with complete dose of RDF resulted in higher P uptake (7.74 kg/ha). The individual effect of amino acid improved the micronutrients, Fe, Zn, Mn and Cu (0.23, 0.04, 0.22 and 0.09 kg/ha). Fe and Zn (0.23 and 0.04 kg/ha) uptake was influenced by humic acid application.

Patil and Madalageri (2003) said that the effect of rock phosphate and P solubilizers on yield and quality of green chilli [Capsicum]. The results revealed that a recommended dose of P< sub>2</ sub>O< sub>5</ sub> (30 kg/ha) applied through rock phosphate along with Bacillus polymyxa [*Paenibacillus polymyxa*] and vermicompost recorded the highest mean fruit yield (74.2 q/ha), ascorbic acid, TSS and P uptake in green chillies over

treatments comprising of rock phosphate with or without Bacillus polymyxa or vermicompost.

Kulkarni *et al.* (2002) conducted an experiment to determine the response of chilli (*Capsicum annuum* cv. Parbhani Tejas) to integrated nutrient supply system. The treatments were control (recommended rate of NPK T_1), and vermicompost at 5 t/ha or soil conditioner (tera care) at 2.5 t/ha combined with 25 and 50% NPK organic booster at 1 liter/m^2 and cowdung urine slurry at 1 liter/m^2. Results revealed that soil conditioner organic booster was the most effective in increaing the height, stem girth, number of branches, number of fruits and greed chilli yield followed by the treatment with vermicompost + organic booster. The application of vermicompost chilli compared to organic and chemical fertilizer alone.

Hangarge *et al.* (2002a) reported that the effects of single or combined applications of vermicompost (5 t/ha), coirpith compost (2.5 t/ha), organic booster (1 litre m^{-2}), cow dung urine slurry (1 litre m^{-2}) and NPK fertilizer (25, 50 and 100%) on the yield and nutrient uptake of chilli (*Capsicum annuum*) cv. Parbhani Tajes were determined in a field experiment conducted in Parbhani, Maharashtra, India, during 1996-97. Application of coirpith compost+organic booster resulted in the highest yield (105.67 q/ha), yield components and N (51.10 kg/ha), P (5.39 kg/ha) and K (49.34 kg/ha) uptake of chilli.

Hangarge *et al.* (2002b) indicated that application of soil conditioner @ 2.5 t/ha in combination with organic booster @ 1 litre per m^2 improved the physical condition of soil by reducing bulk density, increasing porosity, water holding capacity and infiltration rate. The yields of green chilli and spinach were significantly increased due to application of soil conditioner and vermicompost along with organic booster as compared to recommended dose of NPK.

Hangarge *et al.* (2001) conducted an experiment that soil conditioner+organic booster was the most effective in increasing the height, stem girth, number of branches, number of fruits and green chilli yield, followed by the treatment

with vermicompost+organic booster. The application of vermicompost or soil conditioner in combination with chemical and organic fertilizers significantly increased growth and yield attributes of chilli compared to organic and chemical fertilizers alone.

Patil and Biradar (2001) reported that the dry chilli yield and total uptake of nutrient by plant varied significantly with respect to plant population and nutrient levels. A wider spaced plant population of 55 555 plants/ha recorded significantly higher dry chilli yield (20.71 q/ha), followed by 37 037 plants/ha (18.68 q/ha) and further decreased with the increase in plant population. Similarly, higher total N uptake (129.6 kg/ha) was recorded at wider spacing of 37 037 plants/ha and decreased with the increasing plant population. The trend was similar with P and K uptake. The yield of chilli also increased significantly with the increase in nutrient supply. The highest fruit yield (19.12 q/ha) was recorded with the application of 200% RDF + FYM + VC. Similarly, N, P and K uptake increased with the increase in nutrient levels.

Sharu and Meerabai (2001) observed that highest fruit yield (9.66 t/ha) was obtained with 50% poultry manure+50% inorganic N. The best keeping quality and highest ascorbic acid content was recorded for 100% poultry manure, 50% inorganic N+50% poultry manure, 25% inorganic N+75% poultry manure, 25% inorganic N+75% vermicompost, 100% vermicompost, 25% inorganic N+75% neem cake, and 100% neem cake. Poultry manure was superior among the organic fertilizers, and a 1:1 ratio of inorganic to organic fertilizer was best for increasing chilli yield and quality.

Youssef *et al.* (2001) carried out an experiment to study the effect of different fertilizers, i.e. mineral (ammonium nitrate and potassium sulphate) and organic manure (cowdung) alone or in combination, on the quantity and quality of chilli under clear polythylene low tunnels. Treatment with 100% organic manure alone combination with ammonium nitrate resulted in taller plants than other treatments. However, fruit dimensions were the highest with organic manure alone.

Renuka and Ravishankar (2001) conducted an experiment by application of biogass slurry + FYM, vermicompost alone have provided maximum fruit size, more number of fruits per plant, while inorganic fertilizers (NPK) recorded the minimum fruit size.

Fugro (2000) reported that the efficacy of several organic manures and organic pesticides, alone and in combination with inorganic fertilizers and chemical pesticides, for the control of leaf curl [pepper leaf curl virus] and die-back (caused by *Colletotrichum capsici*) diseases of chilli (*Capsicum annuum*). The organic manures tested included farmyard manure (FYM), organic manure, organic manure - cellrich, neem cake and vermicompost. The treatment comprising organic manure in combination with NPK superimposed with alternate sprays of organic and chemical pesticides produced the maximum yield of green chilli (166 q/ha). The lowest incidence of leaf curl (2.12%) and die-back (4.03%) was also observed in the same treatment. These results suggest that in lateritic soils like the Konkan region, it is not possible to maximise the crop yield merely with the use of organic manures and organic pesticides. However, the appropriate combination of both organic and inorganic fertilizers and pesticides is needed to maximise the crop yield and manage chilli diseases to a satisfactory level.

Bhardwai *et al.* (2000) shows the effect of organic sources of nutrients, i.e. Farmyard (*Azadirachta indica*) cake and rapeseed (*Brussica campestries* var toria) cake as partial or complex alternative to chemical fertilizer on yield of tomato, okra, cabbage and cauliflower, and its economic feasibility. Application of sole organic sources of nutrients recorded 11-17% lower yield in different vegetable crops.

Rahman (2000) carried out a field experiment at the Bangladesh Agriculturl University, Mymensingh with three levels of fertilizers, viz. 206/141/159, 275/185/250 and 375/225/300 kg per hectare of urea, TSP and MP along with three doses of cowdung (25, 50 and 10 t/ha). He found that most of the growth parameters, yield components and seedling tuber yield were influenced

significantly by NPK fertilizers cowdung. The yield was the highest at the highest dose of NPK fertilizer and cowdung manure.

Shaktawat and Bansal (1999) carried out a field experiment during the winter season of 1993-94 at Udaipur, Rajasthan, India, chilli was given FYM at 5 t/ha, gobar gas slurry (biogas slurry) at 1.66 t/ha^{-1} or celrich (synthetic organic manure) at 2.5 t ha^{-1}, combined with 0, 40, 80 or 120 kg N ha^{-1}, of the organic manures, gober gas slurry gave significantly higher yield and values of yield components that other, while yields and yield component values increase with increasing N rate. There is no interaction between organic manures and N fertilizer.

Sharma *et al.* (1999) examined the application of boron or FYM individually increased the plant height, capitulum diameter, dry matter, yield of seeds and boron concentration and accumulation. The interaction of boron and FYM levels had a significant influence only on boron concentration of stalk and total boron accumulation of chilli. In the absence of boron application, use of highest level of FRM (910 g kg^{-1} soil) significantly increase boron concentration of FYM at lower rate was effective. The interaction of B and FYM levels had no significant effect on the content of hot water soluble soil B. Application of FYM increased apparent availability of native and fertilizer B from to chilli crops.

Shashidhare *et al.* (1998) studied the effects of organic and inorganic fertilizers on growth and yield of chilli [*Capsicum* sp.].Treatment comprised organic sources like FYM (5 t/ha) in combination with 0, 50% or 100% of the recommended dose of fertilzers (RDF; N: P_2O_5 : K_2O at 150 : 75 : 75 kg/ha). Organic sources had no significant influence on fruit yield Application of 100% RDF together with organic fertilizer increased yield (mean 693 kg/ha) significantly over 50% and 0% RDF (558 and 506 kg/ha, respectively).

Verma *et al.* (1997) conducted an experiment in calcareous soils of Forth Bihar with four levels of N: P_2O_5 : K_2O, namely zero level, 60 : 40 : 40, 120 : 80 : 80

and 180 : 120 : 120 kg/ha, and found that the chilli yield increased with increase in NPK fertilizer levels upto 120 : 80 : 80 kg/ha.

BARC (1997) reported that mustard oil cake contains high amount of secondary and micronutrients in addition to N, P and K @ 5.1-5.2, 1.8-1.9 and 1.1-1.3%, respectively.

Elias *et al.* (1997) recommended a dose of 206 kg urea, 141 kg TSP, 159 kg MP and 15 t cowdung/ha for chilli cultivation. However, their recommendation appeared to be erratic when the dose per square meter of bed was considered. The dose recommended for a square meter of bed did not agree with the recommended dose per hectare. Perhaps the authors did not consider that the effective bed are in one hectare of land would be 6350 sq. m.

Hossain and Majid (1997) conducted an experiment on the effect of water hyacinth compost and cow manure as organic fertilizer on gourds, tomatoes and abubergines near Dhaka. The compost was applied alone or in a 2:1 mixture with cow manure to the gourds and in a 1:1 mixture with 180 kg manure to tomatoes and abuergines. Gourd yields were the highest with 180 kg wet compost added per planting hole. Tomato yields were higher with the mixture than with cow manure alone but ambergine yields were similar in the 2 treatments.

Shaheed (1997) investigated the effect of organic manures on yield and quality of rafted chilli. He reported that mustard oil cake (1500 g/plot) as an alternative of cowdung and poultry dropping played an important role in increasing the yield of grafted chilli.

Singh *et al.* (1996) found that the integrated use of organic manures, chemical fertilizer and microbial inoculants as biofertilizers with microbial inoculants (Azospirillum brasilense, Azotobacter chroooccum, and Bacillus polymxa [Paenicacillus poymyxa] and three sources of organic manure (cowdung slurry, poultry manure and need cake). Treatment with 50% N + 25% poultry manure + bilfertilizer resulted in the highest yield and benefit cost ratio (7.72).

Sujatha and Krishnappa (1996) observed higher chilli yield at 120 : 100 : 120 kg NPK + 50 t FYM/Ha. In another experiment, Dixit (1997) noticed better vegetative growth and higher yield at 150 kg N + 20 t FYM along with 100 kg P_2O_5 + 50 K_2O/ha.

Ahmed *et al.* (1993) reported that organic residues such as cowdung @ 20 t/ha in compaction with other fertilizer played an important role in respect of growth and fruit yield of chilli.

Awad and Griesh (1992) observed that the combination of cultivar and fertilizer showed that Maiak given 120 kg N feddan^{-1} produced the greatest seed yield of 69.62 g plant^{-1} (2 year average).

In pot trials by Koul *et al.* (1990) Capsicum plants were supplied with mixed organic manure (containing microbial fertilizer, 10.75% N, 2.03% P_2O_5, 55.93% K_2O, 23.30% total CI and 39.17% organic manure cowdung on a dry weight basis), inorganic fertilizer or no fertilizer). In Capsicum plant height, leaf number/plant chlorophyll content and yield were 20.9 cm, 17.8 leave/plant, 43.4 mg/g and 273.6 g/pot, respectively in plants supplied with organic manure, compared with 19.3 cm, 14.2 leaves/plant, 43.4 ng/pot, respectively, in plnats supplied with in organic fertilizer, and 108.9 g/pot, respectively, in plnats with no fertilizers application.

Nitta *et al.* (1989) conducted an experiment on the effect of application of crop residues and FYM on the root development, plant growth and yield of chilli and some soil properties for seven years. It was found that the yield increase with crop residues was smaller than that with FYM (cowdung). Application of both FYM and crop residues increased yields as much as FYM alone.

Babafoly (1989) reported that poultry manure and cowdung were separated to all other organic residues in terms of growth, vigor and yield of chilli.

Hussain *et al.* (1989) reported that among the organic amendments, oil cakes have been found to be the most prospective because they do not only reduce

nematode development but also stimulate plant growth and supplying plant nutrients of some sorts.

Prezotti *et al.* (1988) stated that application of poultry manure increaed tomato productivity by 48% and improved the proportion of large fruits in the total yield.

Gorlitz (1987) found that increasing soil organic matter content by the application of FYM (cowdung) in chilli improved plant growth in spring increased plant height and seed yield, weight of 1000 seeds in the absence of mineral fertilizer application.

Tilo and Sanvalentin (1984) found that 75% N + 25% N from cowdung produced more yield that the 100% N when 25% - 75% N from cowdung was used the yield decreased again.

Durmitrescu *et al.* (1965) from their experiment on “composts as organic manures of higher fertilizing value” reported that application of vermicompost at the rate of 5 t/ha gave higher total yield of chilli.

Chapter III

Materials & Methods

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from September, 2015 to January, 2016 to study the influence of different manures on growth and yield of five chili germplasm. This chapter includes materials and methods that were used in conducting the experiment and presented below under the following headings:

3.1 Location of the experiment field

The experiment was conducted at Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from September 2015 to January 2016. The location of the experimental site was at $23^0 75^/$ N latitude and $90^0 34^/$ E longitudes with an elevation of 8.45 meter from sea level (Anon, 1989) in Agro-Ecological Zone of Madhupur Tract (AEZ No. 28).

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of May to September and scattered rainfall during the rest of the year. Information regarding average monthly temperature as recorded by Bangladesh Meteorological Department (climate division) during the period of study has been presented in Appendix I.

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8-6.5, ECE-25.28 (Haider *et al.*, 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Plant materials collection

Five chilli germplasm were collected from a research organization of Bangladesh. The places from where these chilli germplasm have been collected are given below.

3.4.1 Germplasm number and source of collection

Germplasm number	Source
G_1 (Tree Chilli)	BARI
G_2 (Surjomukhi)	BARI
G_3 (Bullet)	BARI
G_4 (Agni)	BARI
G_5 (Cayenee)	BARI

3.5 Raising of seedlings

Chilli seedlings were raised in different polybags. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed and 5 kg well rotten cow dung was mixed with the soil. 3-5 seeds were sown on each polybag on 1st September 2015. After sowing, seeds were covered with light soil. The emergence of the seedlings took place within 6 days after sowing. Weeding, mulching and irrigation were done as and when required. After 27 days of seed sowing they are ready for transplanting. On 28th September the seedlings were transplanted to the main field.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A : 5 Chilli germplasm	**Factor B:** 4 levels of manures
G_1: Tree Chili	O_0: No manure
G_2: Surjomukhi	O_1: Cowdung 10 t ha^{-1}
G_3: Bullet	O_2: Vermicompost 5 t ha^{-1}
G_4: Agni	O_3: Mustard oil cake 2 t ha^{-1}
G_5: Cayenee	

There were total 20 treatment combinations were such as:
G_1O_0, G_1O_1, G_1O_2, G_1O_3, G_2O_0, G_2O_1, G_2O_2, G_2O_3, G_3O_0, G_3O_1, G_3O_2, G_3O_3, G_4O_0, G_4O_1, G_4O_2, G_4O_3, G_5O_0, G_5O_1, G_5O_2, G_5O_3.

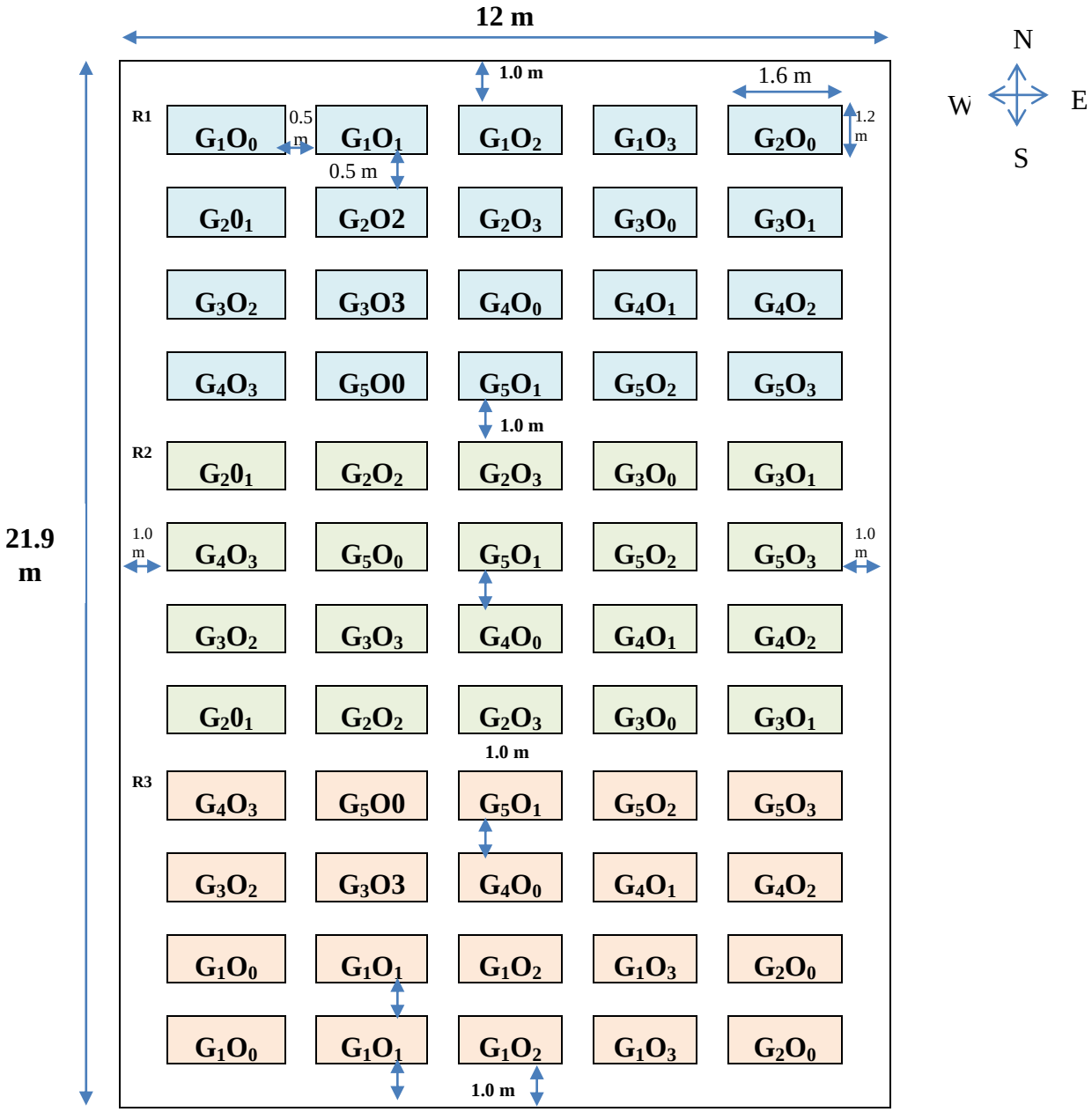
3.7 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. Total area was divided into three equal blocks. Each block was consists of 20 plots where 20 treatments were allotted randomly. There were 60 unit plots in the experiment. The size of a unit plot was 1.6 m × 1.2 m, which accommodated 12 plants at a spacing of 40 cm × 40 cm. The distance between two blocks and two plots were kept 1.0 m and 0.5 m, respectively. A layout of the experiment has been shown in figure 1.

3.8 Cultivation procedure

3.8.1 Land preparation

The soil was well prepared and good tilth was ensured for crop production. The land of the experimental field was ploughed with a power tiller on 15 September, 2015. Later on the land was ploughed three times followed by laddering to obtain desirable tilth.



G_1: Tree Chili, G_2: Surjomukhi, G_3: Bullet, G_4: Agni, G_5: Cayenee;
O_0: No manure, O_1: Cowdung 10 t ha^{-1}, O_2: Vermicompost 5 t ha^{-1}, O_3: Mustard oil cake 2 t ha^{-1}

Spacing : Row to row = 40 cm, Plant to plant = 40 cm; **Unit plot size:** 1.6 m x 1.2 m

Fig 1. Field lay out of the experimental plot

The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was made ready. The field layout and design or the experiment was followed after land preparation.

3.8.2 Manure and fertilizers and its methods of application

Half of Urea, TSP, MoP and Borax fertilizers were given in all unit plots from BARI recommended rate. Different manures were given as per treatment.

Manure	Quantity	Application method
Cowdung	10 t h^{-1}	Basal dose
Vermicompost	5 t h^{-1}	Basal dose
Mustard oil cake	2 t h^{-1}	Basal dose

Source: Razzak *et al.*, (2015)

According to Krishi Projokti Hatboi, the entire amount of cowdung, vermiconpost, mustard oil cake were applied to the plots and incorporated to the soil during final land preparation.

3.8.3 Transplanting of seedlings

Healthy and uniform 21 days old seedlings were uprooted separately from the polybag and were transplanted in the experimental plots in 28th September, 2015 where size of a unit plot was 1.6 m × 1.2 m, which accommodated 12 plants at a spacing of 40 cm × 40 cm. The distance between two blocks and two plots were kept 1.0 m and 0.5 m, respectively. The seedlings were watered after transplanting. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.8.4 Intercultural operations

After transplanting the seedlings, different intercultural operations were accomplished for better growth and development of the plants, which are as follows:

3.8.4.1 Gap filling

When the seedlings were well established, the soil around the base of each seedling was pulverized. A few gaps filling has done by healthy seedlings of the same stock where initial planted seedling failed to survive.

3.8.4.2 Weeding

Numbers of weeding were accomplished as and whenever necessary to keep the crop free from weeds.

3.8.4.3 Irrigation

Number of irrigation was given throughout the growing period by garden pipe, watering cane. The first irrigation was given immediate after the transplantation whereas other were applied when and when required depending upon the condition of soil.

3.8.4.4 Plant protection

The established plants were affected by aphids. Diazinon 60EC (15cc/10 liter) was applied against aphids and other insects. Chilli plants infected with anthracnose and die back were controlled by spraying cupravit (3g/L) at 15 days interval. Few plants found to be infected by bacterial wilt were uprooted.

3.9 Harvesting

Fruits were harvested at 6 to 7 days intervals during early ripe stage when they attained marketable size. Harvesting was started from 15 December, 2015 and was continued up to 05 of January 2016.

3.10 Data collection

Five plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

3.10.1 Plant height

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants was recorded at 15 days interval starting from 20 days of planting up to 65 days to observe the growth rate of plants. The average height was computed and expressed in cm.

3.10.2 Number of branches per plant

Manually counted the number of branch per plant was at 50 days after transplanting from tagged plants. The average of five plants were computed and expressed in average number of branch per plant.

3.10.3 Number of flowers per plant

The number of flowers from the 5 sample plants was counted at 50 days after transplanting.

3.10.4 Number of fruits per plant

The total number of fruits produced in a plant was counted and recorded.

3.10.5 Fruit length

The length of fruit was measured with a meter scale from the neck of the fruit to the bottom of 5 randomly selected marketable fruits from each plot and there average was taken and expressed in cm.

3.10.6 Fruit diameter

Diameter of fruit was measured at the middle portion of 5 randomly selected marketable fruit from each plot with a digital calipers-515 (DC-515) and average was taken and expressed in cm.

3.10.7 Fresh weight of fruit

A digital weighing balance was used to measure the weight of individual fruit from 5 randomly selected marketable fruits from each selected plots and there average was taken and expressed in gram.

3.10.8 Vitamin C content (mg/100g)

Preparation of Dye solution:

Dye = 260 mg	Here,
$NaHCO_3$= 21 mg	Known sample of vitamin C = 10 mg % of
Distilled water = 1L	vitamin C
= 1000 mL	Meta phosphoric acid = 3%
	Titration value of known sample = 5.3

Procedure:

At first 5 gm fruit with 50 ml meta phosphoric acid was blending well in a Blender. Then it was filtered in a 100 ml volumetric flask and was made into 100 mL with meta phosphoric acid. Then 5 ml solution was taken in 250 ml volumetric flask and was titrated with dye solution. Then titration value of each treatment was recorded and was calculated by the following formula:

$$\text{Vitamin C (mg/100g)} = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titrate value

D = Dye factor = $\frac{0.5}{\text{Titrate}}$

V1= Volume to be made (ml)

V2= Volume of extract taken for titration (ml)

W= Weight of sample taken for estimation (g)

3.10.9 Capsaicin content

The determination of capsaicin content was performed by the automatic capsaicin determination machine named “Capsaicin Meter Pro” made in USA, at Postharvest technology division in Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

This is a automatic machine. The fruit sample was meshed and 10 g pest poured to the supplied tube of that machine and switch on the machine. After a few moments the reading was given by the display board.

3.10.10 Yield plant^{-1}

An electric balance was used to measure the weight of fruits per plant. The total fruit yield of each plant measured separately during the harvest period and was expressed in gram (g).

3.10.11 Yield

The total amount of the harvested chilli was recorded, calculated and expressed in kg. The yield per hectare was calculated by the following formula:

$$\text{Fruit yield (ton/ha)} = \frac{\text{Fruit yield per plot (kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.11 Statistical analysis

The data obtained for different characters were statistically analyzed using MSTAT-C software to find out the significance of the difference for different chilli germplasm. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the ‘F’ (variance ratio) test. The significance of the difference among the means of treatment combinations was estimated by LSD at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

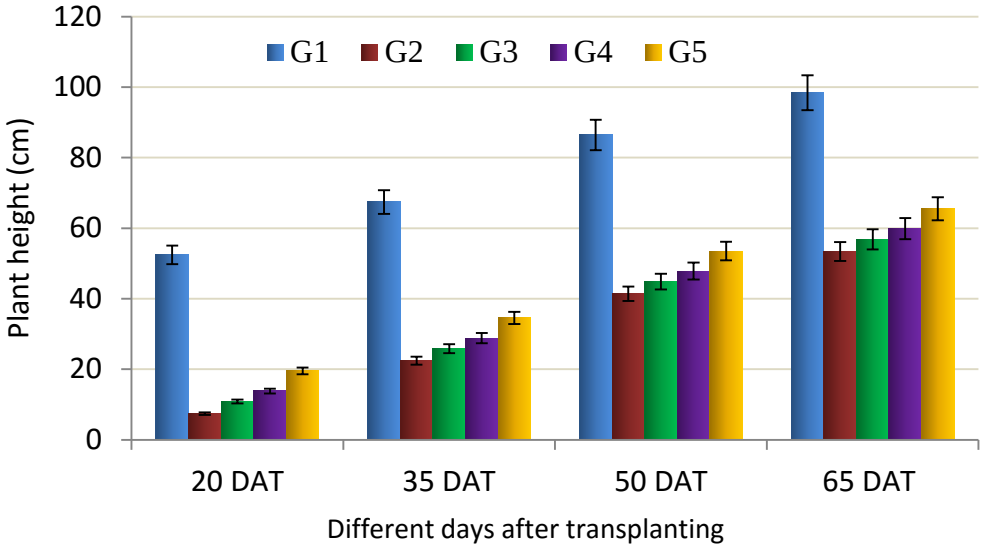
CHAPTER IV
RESULTS AND DISCUSSION

The present study was conducted to find the growth and yield of chili influenced by different organic manures application on different germplasm. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in Appendix III-VI. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings:

4.1 Plant height

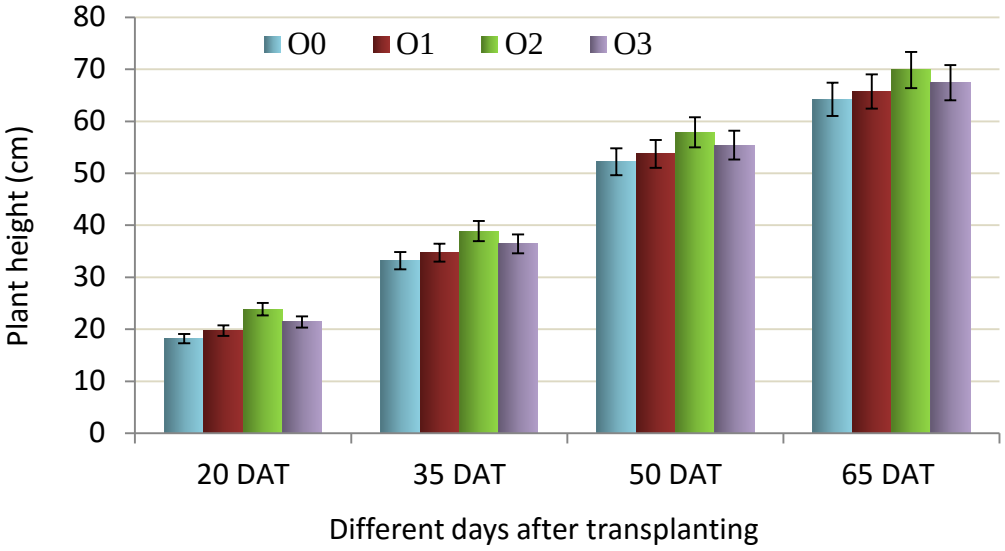
Significant difference was observed due to planting of different germplasm at 20, 35, 50 and 65 DAT (Appendix III). At 20, 35, 50 and 65 DAT, the highest plant height (52.41 cm, 67.41 cm, 86.41 cm and 98.41 cm) was recorded from G_1 (Tree chili) germplasm and on the other hand the shortest plant (7.41 cm, 22.41 cm, 41.41 cm and 53.41 cm) was found from G_2 (Surjomukhi) germplasm (Fig. 2). Tree chili takes slightly more nutrient from soil. It has found in the different experiment that, the growth rate of Tree chili plant is always higher than other germplasm. Long plant height is the genotypic characteristic of this germplasm.

In case of manure application, significant difference was observed at 20, 35, 50 and 65 DAT (Appendix III). At 20, 35, 50 and 65 DAT the highest plant height (23.86 cm, 38.86 cm, 57.86 cm and 69.86 cm) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the shortest plant (18.20 cm, 33.20 cm, 52.21 cm and 64.20 cm) was found from O_0 (Control) treatment (Fig. 3). Vermicompost contains more nutrients than other composts. So that it gives higher growth to the plants. Khandaker *et al.* (2017) observed highest growth, quality and yield performance due to the application of vermicompost. Ishtiyaq *et al.* (2015) also investigated and supported the result.



G_1: Tree Chili, G_2: Surjomukhi, G_3: Bullet, G_4: Agni, G_5: Cayenee

Fig.2. Variation in plant height among all chilli germplasm at different days after transplanting (DAT)



O_0: No manure, O_1: Cowdung 10 t ha^{-1}, O_2: Vermicompost 5 t ha^{-1}, O_3: Mustard oil cake 2 t ha^{-1}

Fig.3. Effect of manure on plant height of chili at different days after transplanting (DAT)

Table 1. Combined effect of germplasm and manure on plant height of chili at different days after transplanting (DAT)

Treatment	Plant Height (cm)			
	20 DAT	**35 DAT**	**50 DAT**	**65 DAT**
G_1O_0	47.00 d	62.01 d	81.00 d	93.01 d
G_1O_1	50.66 c	65.66 c	84.66 c	96.67 c
G_1O_2	59.33 a	74.33 a	93.33 a	105.33 a
G_1O_3	52.66 b	67.66 b	86.66 b	98.67 b
G_2O_0	5.66 q	20.66 q	39.66 q	51.67 q
G_2O_1	6.66 pq	21.66 pq	40.66 pq	52.67 pq
G_2O_2	9.00 no	24.00 no	43.00 no	55.00 no
G_2O_3	8.33 op	23.33 op	42.33 op	54.33 op
G_3O_0	9.66 mno	24.66 mno	43.66 mno	55.67 mno
G_3O_1	10.33 lmn	25.33 lmn	44.33 lmn	56.33 lmn
G_3O_2	12.00 kl	27.01 kl	46.00 kl	58.00 kl
G_3O_3	11.33 klm	26.33 klm	45.33 klm	57.33 klm
G_4O_0	12.33 k	27.33 k	46.33 k	58.33 k
G_4O_1	13.00 jk	28.00 jk	47.01 jk	59.00 jk
G_4O_2	15.66 hi	30.66 hi	49.66 hi	61.67 hi
G_4O_3	14.33 ij	29.33 ij	48.33 ij	60.33 ij
G_5O_0	16.33 gh	31.33 gh	50.33 gh	62.33 gh
G_5O_1	18.00 g	33.00 g	52.00 g	64.00 g
G_5O_2	23.33 e	38.33 e	57.33 e	69.33 e
G_5O_3	20.333 f	35.33 f	54.33 f	66.33 f
LSD $_{(0.05)}$	1.75	1.73	1.72	1.75
CV %	5.10	12.96	11.90	10.59

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_1: Tree Chili
G_2: Surjomukhi
G_3: Bullet
G_4: Agni
G_5: Cayenee

O_0: No manure
O_1: Cowdung 10 t ha^{-1}
O_2: Vermicompost 5 t ha^{-1}
O_3: Mustard oil cake 2 t ha^{-1}

In case of combined effect of germplasm and manure application, significant difference was observed at 20, 35, 50 and 65 DAT (Appendix III). At 20, 35, 50 and 65 DAT the highest plant height (59.33 cm, 74.33 cm, 93.33 cm and 105.33 cm) was obtained from G_1O_2 (Tree chili and Vermi compost 5 t ha^{-1}) treatment combination and on the contrary the shortest plant (5.66 cm, 20.66 cm, 39.66 cm and 51.67 cm) was found from G_2O_0 (Surjomukhi and Control) treatment combination (Table 1). Ali *et al.* (2014) conducted an experiment to investigate the potential of vermicompost and mustard oil cake leachate to chilli and agreed with the similar results. Reshid *et al.* (2014) also conducted experiments to other crops and said that the vermicompost is better than other composts. Mamta *et al.* (2012) conducted experiment on the effect of vermicompost on the growth and productivity of chilli plant and said that plant height was higher in the vermicompost treated field as compared to control and no disease incidence was observed in the fruits of vermicompost treated plot.

4.2 Number of branches $plant^{-1}$

Significant difference in number of branch $plant^{-1}$ was observed due to planting of different germplasm (Appendix IV). The maximum number of branches $plant^{-1}$ (7.33) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum number of branches $plant^{-1}$ (2.69) was found from G_1 (tree chili) germplasm (Table 2).

In case of manure application, significant difference was observed on this character (Appendix IV). The maximum number of branches $plant^{-1}$ (5.44) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum number of branches $plant^{-1}$ (4.62) was found from O_0 (Control) treatment which is statistically identical (4.73) to O_1 (cowdung 10 t ha^{-1}) treatment (Table 3). Vermicompost contains more nutrients than other composts. So that it gives higher growth and branch number of the plants. Singh *et al.* (2014) observed that the effect of organics on growth yield and

biochemical parameters in chilli and observed the higher results in branches number. Khalid *et al.* (2013) also supported the results for the other crops also.

Significant difference was observed on this character due to the combined effect of germplasm and organic manure application (Appendix IV). The maximum number of branches plant^{-1} (8.33) was obtained from G_5O_2 (Cayenee and Vermi compost 5 t ha^{-1}) treatment combination and on the contrary the minimum number of branches plant^{-1} (2.33) was found from G_1O_0 (Tree chili and control) treatment combination which is statistically identical to G_1O_1 (Tree chili and cow dung 10 t ha^{-1}) treatment combination (Table 4). Mamta *et al.* (2012) conducted that the effect of vermicompost on the growth and productivity of chilli plant and said that plant height, number of branches, number of leaves and fruit weight ware higher in the vermicompost treated field as compared to control and no disease incidence was observed in the fruits of vermicompost treated plot.

4.3 Number of flowers plant^{-1}

Significant difference was observed in respect of number of flower plant^{-1} due to planting of different germplasm (Appendix IV). The maximum number of flowers plant^{-1} (152.25) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum number of flowers plant^{-1} (24.00) was found from G_1 (tree chili) germplasm (Table 2).

In case of manure application, significant difference was observed (Appendix IV). The maximum number of flowers plant^{-1} (62.72) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum number of flowers plant^{-1} (55.20) was found from O_0 (Control) treatment. Vermi compost contains more nutrients than other composts. So that it gives higher growth and flowers to the plants. Singh *et al.* (2014) observed that the effect of organics on growth yield and biochemical parameters in chilli and observed the

higher results in leaves number. Vanmathi and Selvakumari (2012) conducted an experiment on other crops and reported that vermicompost adds more nitrogen to the soil and number of leaves increases.

Significant difference was observed due to the combined effect of germplasm and manure application (Appendix IV). The maximum number of flowers plant^{-1} (157.33) was obtained from G_5O_2 (Cayenee and Vermi compost 5 t ha^{-1}) treatment combination and on the contrary the minimum number of flowers plant^{-1} (25.33) was found from G_1O_3 (Tree chili and mustard oilcake 2 t ha^{-1}) treatment combination (Table 4). Mamta *et al.* (2012) conducted that the effect of vermicompost on the growth and productivity of chilli plant and said that number of flowers and fruit weight ware higher in the vermicompost treated field as compared to control and no disease incidence was observed in the fruits of vermicompost treated plot.

4.4 Number of fruits plant^{-1}

Significant difference was observed due to planting of different germplasm (Appendix IV). The maximum number of fruits plant^{-1} (70.75) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum number of fruits plant^{-1} (15.50) was found from G_1 (tree chili) germplasm (Table 2).

In case of manure application, significant difference was observed (Appendix IV). The maximum number of fruits plant^{-1} (37.20) was obtained from O_2 (Vermicompost 5 t ha^{-1}) treatment and on the other hand the minimum number of fruits plant^{-1} (30.06) was found from O_0 (Control) treatment. Vermicompost contains more nutrients than other composts. So that it gives higher growth and fruits to the plants. Ali *et al.* (2011) supported the results. Goutam *et al.* (2011) conducted a field trial and resulted that vermicompost supplemented with chemical fertilizer showed 73% better yield of fruits than control. Cristina and Jorge (2011) reported that vermicompost can fruit production and accelerates the development of a wide range of plant species.

Significant difference was observed due to the interaction effect of germplasm and manure application (Appendix IV). The maximum number of fruits plant^{-1} (75.33) was obtained from G_5O_2 (Cayenee and Vermi compost 5 t ha^{-1}) treatment combination and on the contrary the minimum number of fruits plant^{-1} (16.66) was found from G_1O_3 (Tree chili and mustard oilcake 2 t ha^{-1}) treatment combination (Table 4). Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate with maximum number of leaves, height, leaf length, number of fruits and productivity.

4.5 Fruit length

Significant difference was observed due to planting of different germplasm (Appendix IV). The maximum fruit length (7.31 cm) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum fruit length (3.33 cm) was found from G_1 (tree chili) germplasm (Table 2).

In case of manure application, significant difference was observed (Appendix IV). The maximum fruit length (5.77 cm) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum fruit length (4.77 cm) was found from O_0 (Control) treatment (Table 3). Vermi compost contains more nutrients than other composts. When the plant gets more manure, then the fruit size increases. Joshi and Vig (2010) reported that various growth, yield and quality parameters like mean stem diameter, plant height, fruit length and yield/plant increase significantly when treated with vermicompost.

Significant difference was observed due to the combined effect of germplasm and manure application (Appendix IV). The maximum fruit length (8.46 cm) was obtained from G_5O_2 (Cayenee and Vermi compost 5 t ha^{-1}) treatment combination and on the contrary the minimum fruit length (3.40 cm) was found from G_1O_3 (Tree chili and mustard oilcake 2 t ha^{-1}) treatment combination (Table 4). Manatad and Jaquias (2008) evaluated growth and yield performance

of vegetables as influenced by the application of different rates of vermicompost.

Table 2. Variation in number of branches plant^{-1}, number of flowers plant^{-1}, number of fruits plant^{-1} and fruit length among germplasm of chili

Treatment	Number of branches plant^{-1}	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Fruit length (cm)
G_1	2.69 e	24.00 e	15.50 e	3.33 e
G_2	3.95 d	30.73 d	21.25 d	4.42 d
G_3	4.83 c	36.50 c	26.08 c	5.15 c
G_4	6.06 b	50.75 b	34.83 b	5.99 b
G_5	7.33 a	152.25 a	70.75 a	7.31 a
LSD $_{(0.05)}$	0.32	0.88	0.99	0.12
CV %	7.80	5.82	3.57	6.80

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_1: Tree Chili, G_2: Surjomukhi, G_3: Bullet, G_4: Agni, G_5: Cayenee

Table 3. Effect of manure on number of branches plant^{-1}, number of flowers plant^{-1}, number of fruits plant^{-1} and Fruit length of chili

Treatment	Number of branches plant^{-1}	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Fruit length (cm)
O_0	4.62 c	55.20 d	30.06 d	4.77 d
O_1	4.73 c	57.66 c	32.93 c	5.11 c
O_2	5.44 a	62.72 a	37.20 a	5.77 a
O_3	5.11 b	59.80 b	34.53 b	5.32 b
LSD $_{(0.05)}$	0.28	0.79	0.88	0.108
CV %	7.80	5.82	3.57	6.80

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

O_0: No manure, O_1: Cowdung 10 t ha^{-1}, O_2: Vermicompost 5 t ha^{-1}, O_3: Mustard oil cake 2 t ha^{-1}

Table 4. Combined effect of germplasm and manure on number of branches plant^{-1}, number of flowers plant^{-1}, number of fruits plant^{-1} and fruit length of chili

Treatment	Number of branches plant^{-1}	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Fruit length (cm)
G_1O_0	2.33 l	20.67 o	12.00 o	2.76 m
G_1O_1	2.36 l	22.33 o	16.00 n	3.20 l
G_1O_2	3.20 jk	27.67 m	17.33 mn	3.96 k
G_1O_3	2.90 kl	25.33 n	16.66 n	3.40 l
G_2O_0	3.83 ij	28.33 lm	18.66 m	4.06 k
G_2O_1	4.00 i	30.00 l	21.00 l	4.20 k
G_2O_2	4.00 i	32.60 k	23.66 k	4.83 ij
G_2O_3	4.00 i	32.00 k	21.60 l	4.60 j
G_3O_0	4.33 hi	33.67 jk	24.00 k	5.00 hi
G_3O_1	4.66 gh	34.67 j	25.33 jk	5.03 hi
G_3O_2	5.33 ef	40.67 h	28.33 hi	5.43 g
G_3O_3	5.00 fg	37.00 i	26.66 ij	5.16 h
G_4O_0	5.93 de	46.33 g	30.00 h	5.70 f
G_4O_1	6.00 d	50.00 f	32.33 g	6.03 e
G_4O_2	6.33 cd	55.33 e	41.33 e	6.16 de
G_4O_3	6.00 d	51.33 f	35.66 f	6.06 e
G_5O_0	6.66 c	147.00 d	65.66 d	6.33 d
G_5O_1	6.66 c	151.33 c	70.00 c	7.10 c
G_5O_2	8.33 a	157.33 a	75.33 a	8.46 a
G_5O_3	7.66 b	153.33 b	72.00 b	7.36 b
LSD $_{(0.05)}$	0.64	1.76	1.98	0.24
CV %	7.80	5.82	3.57	6.80

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_1: Tree Chili
G_2: Surjomukhi
G_3: Bullet
G_4: Agni
G_5: Cayenee

O_0: No manure
O_1: Cowdung 10 t ha^{-1}
O_2: Vermicompost 5 t ha^{-1}
O_3: Mustard oil cake 2 t ha^{-1}

Findings of their study exposed that fruit length, diameter, weight of fruits/plant and yield was significantly enhanced by vermicompost application in chilli.

4.6 Fruit diameter

Significant difference was observed due to planting of different germplasm (Appendix V). The maximum fruit diameter (3.54 cm) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum fruit diameter (1.06 cm) was found from G_1 (tree chili) germplasm (Table 5).

In case of manure application, significant difference was observed (Appendix V). The maximum fruit diameter (2.02 cm) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum fruit diameter (1.70 cm) was found from O_0 (Control) treatment (Table 6). Vermi compost contains more nutrients than other composts. When the plant gets more manure, then the fruit size increases.

Significant difference was observed due to the interaction effect of germplasm and manure application (Appendix V). The maximum fruit diameter (3.90 cm) was obtained from G_5O_2 (Cayenee and Vermi compost 5 t ha^{-1}) treatment combination and on the contrary the minimum fruit diameter (0.96 cm) was found from G_1O_0 (Tree chili and control) treatment combination which is statistically identical (1.00 cm) to G_1O_1 (Tree chili and cowdung 10 t ha^{-1}) and statistically similar (1.10) to G_1O_3 (Tree chili and mustard oilcake 2 t ha^{-1}) treatment combination (Table 7). Manatad and Jaquias (2008) evaluated growth and yield performance of chilli as influenced by the application of different rates of vermicompost. Findings of their study exposed that fruit length, diameter, weight of fruits/plant and yield was significantly enhanced by vermicompost application.

4.7 Fresh weight of fruit

Significant difference was observed due to planting of different germplasm (Appendix V). The maximum fresh weight of fruit (6.21 g) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum fresh weight of fruit (2.74 g) was found from G_1 (tree chili) germplasm (Table 5).

In case of manure application, significant difference was observed (Appendix V). The maximum fresh weight of fruit (4.97 g) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum fresh weight of fruit (4.18 g) was found from O_0 (Control) treatment (Table 6). Vermi compost contains more nutrients than other composts. When the plant gets more manure, then the fruit size increases. Manure helps to accumulate the dry matter to the plant. Joshi and Vig (2010) reported that various growth, yield and quality parameters like mean stem diameter, plant height, fruit length and yield/plant increase significantly when treated with vermicompost.

Significant difference was observed due to the interaction effect of germplasm and manure application (Appendix V). The maximum fresh weight of fruit (6.93 g) was obtained from G_5O_2 (Cayenee and Vermi compost 5 t ha^{-1}) treatment combination and on the contrary the minimum fresh weight of fruit (2.16 g) was found from G_1O_0 (Tree chili and control) treatment combination (Table 7). Manatad and Jaquias (2008) evaluated growth and yield performance chilli as influenced by the application of different rates of vermicompost and exposed that weight of fruits/plant and yield was significantly enhanced by vermicompost application. Ullah *et al.* (2008) reported that fruit weight increases by organic manure.

4.8 Vitamin C content

Significant difference was observed due to planting of different germplasm (Appendix V). The maximum vitamin C content (149.96 mg/100g) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum vitamin C content (94.51 mg/100g) was found from G_1 (tree chili) germplasm (Table 5).

In case of manure application, significant difference was observed (Appendix V). The maximum vitamin C content (128.27 mg/100g) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum vitamin C content (105.77 mg/100g) was found from O_0 (Control) treatment (Table 6). Mamta *et al.* (2005) observed that the efficacy of several organic manures can produces good products which are chemically sound with its elements.

Significant difference was observed due to the interaction effect of germplasm and manure application (Appendix V). The maximum vitamin C content (161.33 mg/100g) was obtained from G_5O_3 (Cayenee and mustard oil cake 2 t ha^{-1}) treatment combination and on the contrary the minimum vitamin C content (92.50 mg/100g) was found from G_1O_1 (Tree chili and cowdung 10 t ha^{-1}) treatment combination which is statistically identical to G_1O_0 (Tree chili and control) treatment combination (Table 7). Anju *et al.* (2006) studied that the influence of organic manures and supported the results. Arancon *et al.* (2006b) found that vermicompost produced commercially viable products from the plant.

Table 5. Variation in fruit diameter, fresh weight of fruit and vitamin C content among chilli germplasm

Treatment	Fruit diameter (cm)	Fresh weight of fruit (g)	Vitamin C content (mg/100g)
G_1	1.06 e	2.74 e	94.51 e
G_2	1.30 d	3.99 d	101.45 d
G_3	1.55 c	4.56 c	111.02 c
G_4	1.80 b	5.25 b	126.65 b
G_5	3.54 a	6.21 a	149.96 a
$LSD_{(0.05)}$	0.08	0.102	0.68
CV %	5.35	6.74	5.65

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_1: Tree Chili, G_2: Surjomukhi, G_3: Bullet, G_4: Agni, G_5: Cayenee

Table 6. Effect of manure on fruit diameter, fresh weight of fruit and vitamin C content of chili

Treatment	Fruit diameter (cm)	Fresh weight of fruit (g)	Vitamin C content (mg/100g)
O_0	1.70 d	4.18 d	105.77 d
O_1	1.78 c	4.42 c	115.70 c
O_2	2.02 a	4.97 a	117.12 b
O_3	1.89 b	4.63 b	128.27 a
$LSD_{(0.05)}$	0.07	0.09	0.60
CV %	5.35	6.74	5.65

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

O_0: No manure, O_1: Cowdung 10 t ha^{-1}, O_2: Vermicompost 5 t ha^{-1}, O_3: Mustard oil cake 2 t ha^{-1}

Table 7. Combined effect of germplasm and manure on fruit diameter, fresh weight of fruit and vitamin C content of chili

Treatment	Fruit diameter (cm)	Fresh weight of fruit (g)	Vitamin C content (mg/100g)
G_1O_0	0.96 m	2.16 n	93.43 n
G_1O_1	1.00 m	2.40 m	92.50 n
G_1O_2	1.20 kl	3.50 k	94.93 m
G_1O_3	1.10 lm	2.90 l	97.17 l
G_2O_0	1.26 jk	3.80 j	96.27 lm
G_2O_1	1.26 jk	4.00 ij	98.57 k
G_2O_2	1.36 ij	4.13 hi	100.10 j
G_2O_3	1.30 jk	4.03 i	110.87 h
G_3O_0	1.46 hi	4.30 h	103.50 i
G_3O_1	1.46 hi	4.56 g	111.93 h
G_3O_2	1.66 g	4.76 g	113.50 g
G_3O_3	1.60 gh	4.63 g	115.13 f
G_4O_0	1.66 g	5.00 f	114.13 fg
G_4O_1	1.73 fg	5.20 ef	117.23 e
G_4O_2	2.00 e	5.53 d	118.37 e
G_4O_3	1.83 f	5.30 e	156.87 c
G_5O_0	3.16 d	5.66 d	121.52 d
G_5O_1	3.46 c	5.96 c	158.27 b
G_5O_2	3.90 a	6.93 a	158.70 b
G_5O_3	3.63 b	6.30 b	161.33 a
$LSD_{(0.05)}$	0.16	0.20	1.36
CV %	5.35	6.74	5.65

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_1: Tree Chili
G_2: Surjomukhi
G_3: Bullet
G_4: Agni
G_5: Cayenee

O_0: No manure
O_1: Cowdung 10 t ha^{-1}
O_2: Vermicompost 5 t ha^{-1}
O_3: Mustard oil cake 2 t ha^{-1}

4.9 Capsaicin content

Significant difference was observed due to planting of different germplasm (Appendix VI). The maximum capsaicin content (1.64 %) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum capsaicin content (0.77 %) was found from G_1 (tree chili) germplasm (Table 8).

In case of manure application, significant difference was observed (Appendix VI). The maximum capsaicin content (1.23 %) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum capsaicin content (1.02 %) was found from O_0 (Control) treatment (Table 9). Ali *et al.* (2014) conducted an experiment and supported the finding.

Significant difference was observed due to the interaction effect of germplasm and manure application (Appendix VI). The maximum capsaicin content (1.76 %) was obtained from G_5O_2 (Cayenee and vermi compost 5 t ha^{-1}) treatment combination which is statistically identical (1.83 %) to G_5O_3 (Cayenee and mustard oil cake 2 t ha^{-1}) and on the contrary the minimum capsaicin content (0.70 %) was found from G_1O_1 (Tree chili and cowdung 10 t ha^{-1}) treatment combination which is statistically identical to G_1O_0 (Tree chili and control) treatment combination (Table 10). Singh *et al.* (2014) agreed with the results.

4.10 Yield $plant^{-1}$

Significant difference was observed due to planting of different germplasm (Appendix VI). The maximum yield $plant^{-1}$ (371.27 g) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum yield $plant^{-1}$ (47.57 g) was found from G_1 (tree chili) germplasm (Table 8).

In case of manure application, significant difference was observed (Appendix VI). The maximum yield $plant^{-1}$ (200.74 g) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum yield $plant^{-1}$ (131.71 g) was found from O_0 (Control) treatment (Table 9). Subhasmita *et al.*

(2004) shows the effects of vermicompost based on karanj, niger, mahua, Indian mustard, groundnut or neem oilseed cake, whereas the vermicompost based on groundnut oilseed cake recorded the highest fruit yield (21.3 g per plant).

Table 8. Variation in capsaicin content, yield plant^{-1} and yield ha^{-1} among germplasm of chili

Treatment	Capsaicin content (%)	Yield plant^{-1} (g)	Yield ha^{-1} (t/ha)
G_1	0.77 e	47.57 e	1.92 e
G_2	0.91 d	83.18 d	3.31 d
G_3	1.04 c	116.18 c	4.77 c
G_4	1.20 b	213.06 b	8.70 b
G_5	1.64 a	371.27 a	14.51 a
LSD $_{(0.05)}$	0.05	9.39	0.37
CV %	6.19	6.84	6.82

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_1: Tree Chili, G_2: Surjomukhi, G_3: Bullet, G_4: Agni, G_5: Cayenee

Table 9. Effect of manure on capsaicin content, yield plant^{-1} and yield ha^{-1} of chili

Treatment	Capsaicin content (%)	Yield plant^{-1} (g)	Yield ha^{-1} (t/ha)
O_0	1.02 d	131.71 d	4.85 d
O_1	1.10 c	158.20 c	6.33 c
O_2	1.15 b	200.74 a	8.43 a
O_3	1.23 a	174.35 b	6.96 b
LSD $_{(0.05)}$	0.05	8.40	0.33
CV %	6.19	6.84	6.82

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

O_0: No manure, O_1: Cowdung 10 t ha^{-1}, O_2: Vermicompost 5 t ha^{-1}, O_3: Mustard oil cake 2 t ha^{-1}

Table 10. Combined effect of germplasm and manure on capsaicin content, yield plant^{-1} and yield ha^{-1} of chili

Treatment	Capsaicin content (%)	Yield plant^{-1} (g)	Yield ha^{-1} (t/ha)
G_1O_0	0.70 k	29.57 o	1.16 o
G_1O_1	0.71 k	43.90 no	1.76 no
G_1O_2	0.90 ij	63.93 lm	2.66 lm
G_1O_3	0.78 jk	52.87 mn	2.10 mn
G_2O_0	0.74 k	66.63 lm	2.60 lm
G_2O_1	0.94 hi	80.90 kl	3.23 kl
G_2O_2	0.96 hi	97.60 jk	3.93 jk
G_2O_3	1.00 ghi	87.57 k	3.50 k
G_3O_0	0.98 ghi	98.67 jk	3.90 jk
G_3O_1	1.03 fgh	108.60 ij	4.33 ij
G_3O_2	1.03 fgh	133.37 gh	5.90 g
G_3O_3	1.13 f	124.10 hi	4.96 hi
G_4O_0	1.10 fg	148.33 g	5.33 gh
G_4O_1	1.26 e	192.77 f	7.73 f
G_4O_2	1.30 de	282.03 d	12.60 c
G_4O_3	1.43 c	229.10 e	9.13 e
G_5O_0	1.40 cd	315.37 c	11.26 d
G_5O_1	1.56 b	364.83 b	14.60 b
G_5O_2	1.76 a	426.77 a	17.06 a
G_5O_3	1.83 a	378.10 b	15.13 b
LSD $_{(0.05)}$	0.11	18.78	0.74
CV %	6.19	6.84	6.82

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_1: Tree Chili
G_2: Surjomukhi
G_3: Bullet
G_4: Agni
G_5: Cayenee

O_0: No manure
O_1: Cowdung 10 t ha^{-1}
O_2: Vermicompost 5 t ha^{-1}
O_3: Mustard oil cake 2 t ha^{-1}

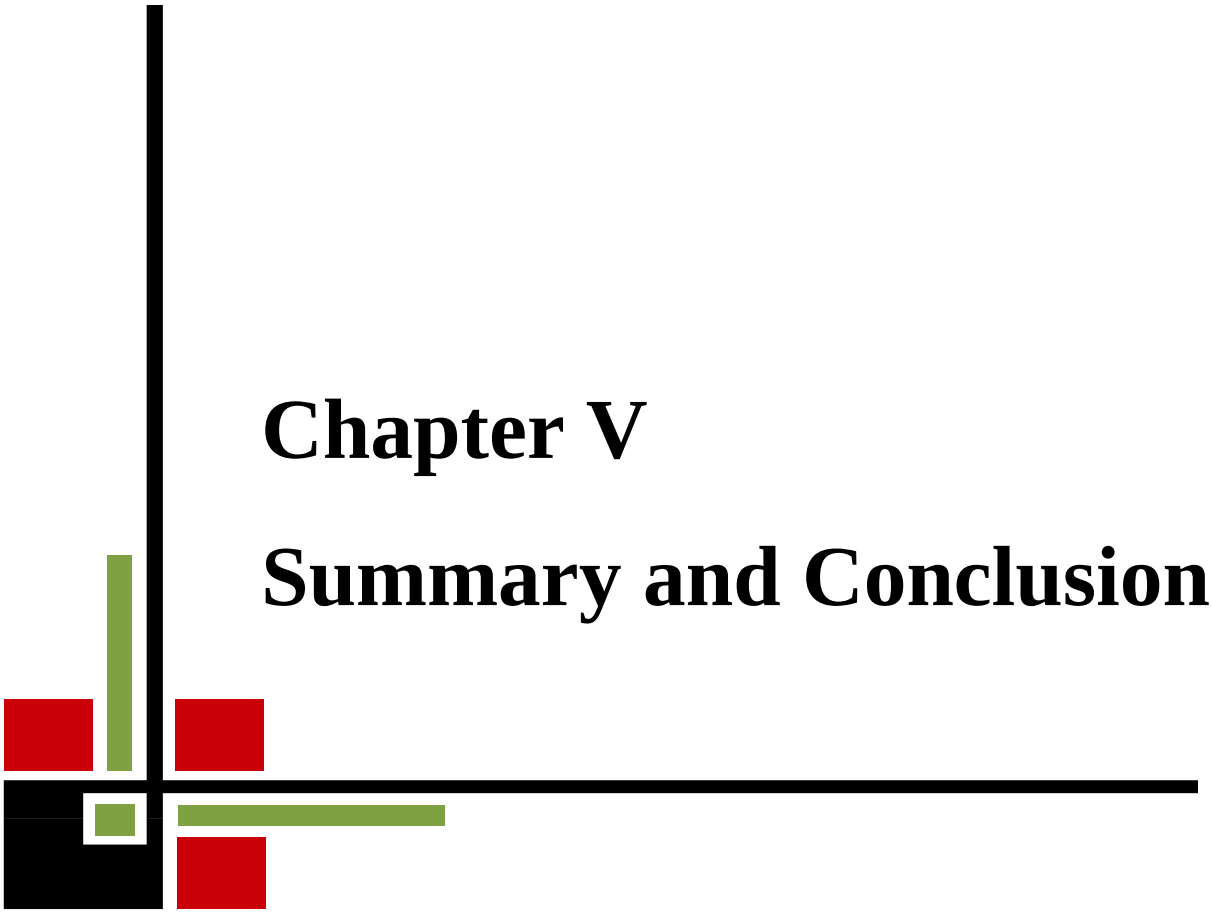
Significant difference was observed due to the interaction effect of germplasm and manure application (Appendix VI). The maximum yield plant^{-1} (426.77 g) was obtained from G_5O_2 (Cayenee and vermi compost 5 t ha^{-1}) treatment combination and on the contrary the minimum yield plant^{-1} (29.57 g) was found from G_1O_0 (Tree chili and control) treatment combination which is statistically similar to (43.90 g) G_1O_1 (Tree chili and cowdung 10 t ha^{-1}) treatment combination (Table 10). Yadav and Vijayakumari (2004) reported that vermicompost produces more yield per plant. Patil and Madalageri (2003) said that vermicompost recorded the highest mean fruit yield (74.2 q/ha). Hangarge *et al.* (2002a) conducted that the effects of single or combined applications of vermicompost (5 t/ha) on chilli resulted in the highest yield.

4.11 Yield

Significant difference was observed due to planting of different germplasm (Appendix VI). The maximum yield hectare^{-1} (14.51 ton) was recorded from G_5 (Cayenee) germplasm and on the other hand the minimum yield hectare^{-1} (1.92 ton) was found from G_1 (tree chili) germplasm (Table 8).

In case of manure application, significant difference was observed (Appendix VI). The maximum yield hectare^{-1} (8.43 ton) was obtained from O_2 (Vermi compost 5 t ha^{-1}) treatment and on the other hand the minimum yield hectare^{-1} (4.85 ton) was found from O_0 (Control) treatment (Table 9). Sharu and Meerabai (2001) observed that highest fruit yield obtained from vermicompost. Shashidhare *et al.* (1998) studied the effects of manure on chilli and supported the results. Kumar *et al.* (2013) reported the similar results. Mamta *et al.* (2012) conducted that the effect of vermicompost on the growth and productivity of chilli plant and said that number of flowers, fruit weight and yield ware higher in the vermicompost treated field as compared to control and no disease incidence was observed in the fruits of vermicompost treated plot.

Significant difference was observed due to the interaction effect of germplasm and manure application (Appendix VI). The maximum yield hectare^{-1} (17.06 ton) was obtained from G_5O_2 (Cayenee and vermi compost 5 t ha^{-1}) treatment combination and on the contrary the minimum yield hectare^{-1} (1.16 ton) was found from G_1O_0 (Tree chili and control) treatment combination which is statistically similar (1.76 ton) to G_1O_1 (Tree chili and cowdung 10 t ha^{-1}) treatment combination (Table 10). Joshi and Vig (2010) reported that various growth, yield and quality parameters like mean stem diameter, plant height, fruit length and yield/plant increase significantly when treated with vermicompost. Tharmaraj *et al.* (2011) narrated that vermicompost treated plants exhibit faster and higher growth rate with maximum number of leaves, height, leaf length, number of fruits and productivity. Goutam *et al.* (2011) conducted a field trial and resulted that vermicompost supplemented with chemical fertilizer showed 73% better yield of fruits than control.



Chapter V

Summary and Conclusion

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from September 2015 to January 2016 to find out the influence of manure on growth and yield of five chili germplasm. The experiment consisted of two factors: Factor A: Five chili germplasm, viz. $G_{1:}$ Tree chili, $G_{2:}$ Surjomukhi, G_3: Bullet, G_4: Agni, G_5: Cayenne. Factor B: 4 levels of manures, viz. O_0: no manure (control), O_1: Cowdung 10 t ha^{-1}, O_2: Vermicompost 5 t ha^{-1},O_3: Mustard oil cake 2 t ha^{-1}. There were 20 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the best manure for better growth and yield of those chili germplasm.

In case of different germplasm the maximum plant height at 65 DAT, 98.41 cm was obtained from G_1 germplasm. In other cases the maximum number of branches $plant^{-1}$ (7.33), maximum number of flowers $plant^{-1}$ (152.25), maximum number of fruits $plant^{-1}$ (70.75), maximum fruit length (7.31 cm), maximum fruit diameter (3.54 cm), maximum fresh weight of fruit (6.21 g), maximum vitamin C content (149.96 mg/100g), maximum capsaicin content (1.64 %), maximum yield $plant^{-1}$ (371.27 g), maximum yield ha^{-1} (14.51 t/ha) were recorded from G_5 that is Cayenee which is a well known variety. On the other hand, the minimum plant height at 65 DAT, 53.41 cm was obtained from G_2 that is Surjomukhi germplasm and the minimum number of branches $plant^{-1}$ (2.69), minimum number of flowers $plant^{-1}$ (24.00), minimum number of fruits $plant^{-1}$ (15.50), minimum fruit length (3.33 cm), minimum fruit diameter (1.06 cm), minimum fresh weight of fruit (2.74 g), minimum vitamin c content (94.51 mg/100g), minimum capsaicin content (0.77 %), minimum yield $plant^{-1}$ (47.57 g), minimum yield ha^{-1} (1.92 t/ha) were recorded from G_1 that is tree chili germplasm.

In case of different manure application, the maximum plant height at 65 DAT, 69.86 cm was obtained from O_2 treatment. In other cases the maximum number of branches plant^{-1} (5.44), maximum number of flowers plant^{-1} (62.72), maximum number of fruits plant^{-1} (37.20), maximum fruit length (5.77 cm), maximum fruit diameter (2.02 cm), maximum fresh weight of fruit (4.97 g), maximum yield plant^{-1} (200.74 g), maximum yield ha^{-1} (8.43 t/ha) were recorded from O_2 treatment that is vermi compost 5 t ha^{-1} but the maximum vitamin C content (128.27 mg/100g) and maximum capsaicin content (1.23 %) were recorded from O_3 treatment that is mustard oil cake 2 t ha^{-1}. On the other hand, minimum plant height at 65 DAT, 64.20 cm , the minimum number of branches plant^{-1} (4.62), minimum number of flowers plant^{-1} (55.20), minimum number of fruits plant^{-1} (30.06), minimum fruit length (4.77 cm), minimum fruit diameter (1.70 cm), minimum fresh weight of fruit (4.18 g), minimum vitamin c content (105.77 mg/100g), minimum capsaicin content (1.02 %), minimum yield plant^{-1} (131.71 g), minimum yield ha^{-1} (4.85 t/ha) were recorded from O_0 treatment that is control treatment.

In case of interaction effect of germplasm and different manure application, the maximum plant height at 65 DAT, 105.33 cm was obtained from G_1O_2 treatment combination (Tree chili and vermi compost 5 t ha^{-1}). In other cases the maximum number of branches plant^{-1} (8.33), maximum number of flowers plant^{-1} (157.33), maximum number of fruits plant^{-1} (75.33), maximum fruit length (8.46 cm), maximum fruit diameter (3.90 cm), maximum fresh weight of fruit (6.93 g), maximum yield plant^{-1} (426.77 g), maximum yield ha^{-1} (17.06 t/ha) were recorded from G_5O_2 treatment combination that is vermi compost 5 t ha^{-1} with Cayenee germplasm but the maximum vitamin C content (161.33 mg/100g) and maximum capsaicin content (1.83 %) were recorded from G_5O_3 treatment combination that is mustard oil cake 2 t ha^{-1} with Cayenee. On the contrary, minimum plant height at 65 DAT, 51.67 cm recorded from G_2O_0 treatment combination, the minimum number of branches plant^{-1} (2.33), minimum number of flowers plant^{-1} (20.67), minimum number of fruits plant^{-1} (12.00), minimum fruit length (2.76 cm), minimum fruit diameter (0.96 cm),

minimum fresh weight of fruit (2.16 g), minimum capsaicin content (0.70 %), minimum yield plant^{-1} (29.57 g), minimum yield ha^{-1} (1.16 t/ha) were recorded from G_1O_0 treatment combination that is control treatment with Tree chili and minimum vitamin C content (92.50 mg/100g) was obtained from G_1O_1 treatment combination that is cowdung 10 t ha^{-1} treatment with Tree chili.

Conclusion

Based on the result of the present study it was found that application of 5 t vermicompost ha^{-1} with Cayenee germplasm performed the highest yield (17.06 t ha^{-1}) for chili production in field condition. This treatment combination also shows higher result in most of the growth parameters. Considering the findings of the experiment, it can be concluded that -

The combination of 5 t vermicompost ha^{-1} with Cayenee germplasm may be the appropriate practice to get maximum quality yield.

Further research should be done with more germplasm of chili and setting more manure treatments in different locations of the country to get the more appropriate and acceptable results.

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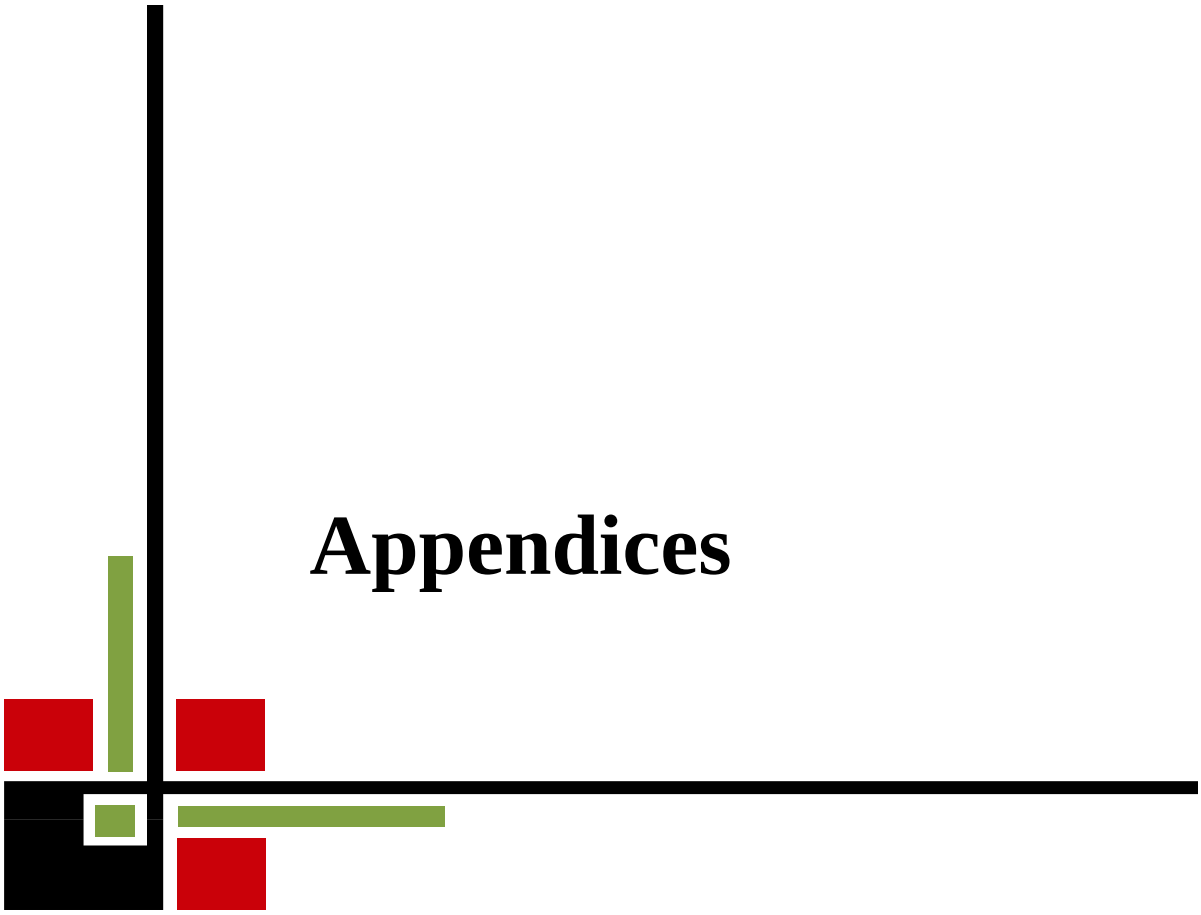


Appendices

APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2015 to May 2016

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
October,15	29.18	18.26	81	39
November,15	25.82	16.04	78	0
December,15	22.4	13.5	74	0
January,16	24.5	12.4	68	0
February,16	27.1	16.7	67	3
March,16	31.4	19.6	54	11
April, 16	35.3	22.4	51	15
May, 16	38.2	23.2	62	17

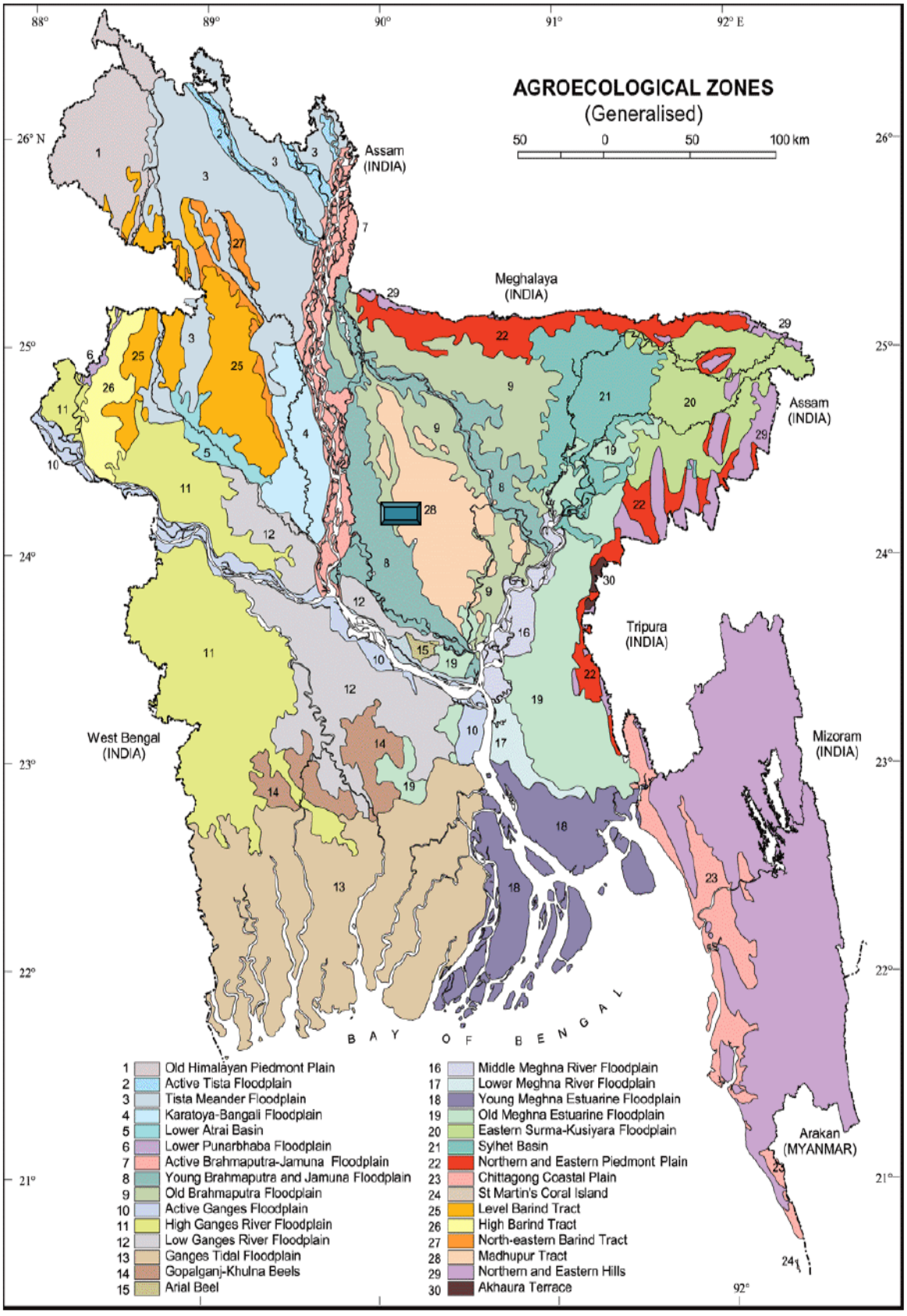
Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Experimental site on the AEZ map of Bangladesh



C. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

D. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix-III. Analysis of variance of data on plant height (cm) at different days after transplanting of chili

Source of variation	Degrees of freedom (df)	Mean square of plant height at			
		20 DAT	35 DAT	50 DAT	65 DAT
Replication	2	3.651	3.650	3.650	3.650
Factor A (Germplasm)	3	3984.780**	3984.841**	3984.881*	3984.86**
Factor B (Manure)	2	88.310*	88.312*	88.311*	88.310*
Interaction (A X B)	6	9.101*	9.101*	9.101*	9.100**
Error	22	1.120	1.120	1.120	1.120
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-IV. Analysis of variance of data on number of branches plant^{-1}, number of flowers plant^{-1}, number of fruits plant^{-1} and Fruit length of chili

Source of variation	Degrees of freedom (df)	Mean square of number of			
		No. of branches plant^{-1}	No. of flowers plant^{-1}	No. of fruits plant^{-1}	Fruit length (cm)
Replication	2	13.410	6.200	4.872	1.261
Factor A (Germplasm)	3	39.061*	33881.30**	5754.721**	27.551*
Factor B (Manure)	2	2.091*	153.010*	133.661*	2.621*
Interaction (A X B)	6	0.282*	3.301**	7.041**	0.261*
Error	22	0.152	1.101	1.451	0.022
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-V. Analysis of variance of data on fruit diameter, fresh weight of fruit and vitamin C content of chili

Source of variation	Degrees of freedom (df)	Mean square of number of		
		Fruit diameter (cm)	Fresh weight of fruit (g)	Vitamin C content (mg/100 gm)
Replication	2	0.007	0.039	0.29
Factor A (Germplasm)	3	11.608*	20.584**	5886.85*
Factor B (Manure)	2	0.288*	1.666*	1272.77*
Interaction (A X B)	6	0.032*	0.147*	314.05*
Error	22	0.009	0.015	0.68
** : Significant at 1% level of probability; * : Significant at 5% level of probability				

Appendix-VI. Analysis of variance of data on capsaicin content, yield plant^{-1} and yield ha^{-1} of chili

Source of variation	Degrees of freedom (df)	Mean square of		
		Capsaicin content (%)	Yield plant^{-1} (g)	Yield ha^{-1} (t/ha)
Replication	2	0.014	350.00	0.554
Factor A (Germplasm)	3	1.390*	203150.00**	309.118**
Factor B (Manure)	2	0.118*	12563.00*	33.044*
Interaction (A X B)	6	0.032*	1302.00*	4.113*
Error	22	0.004	129.00	0.205
** : Significant at 1% level of probability; * : Significant at 5% level of probability				